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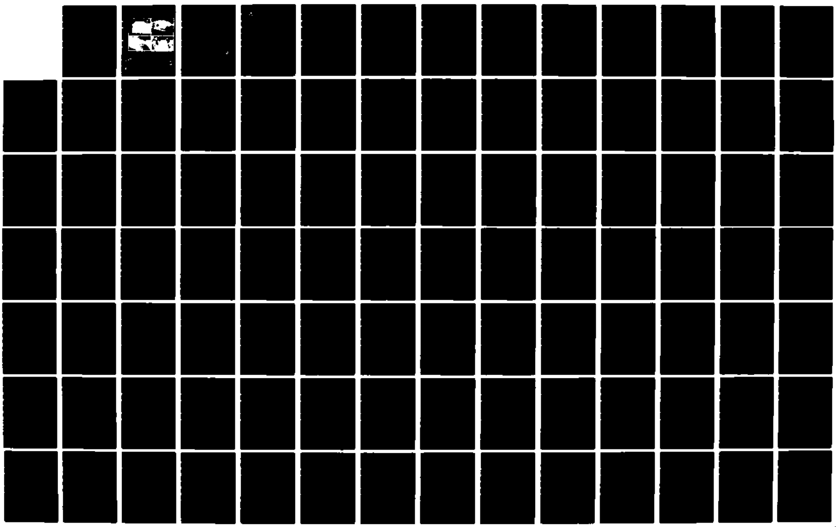

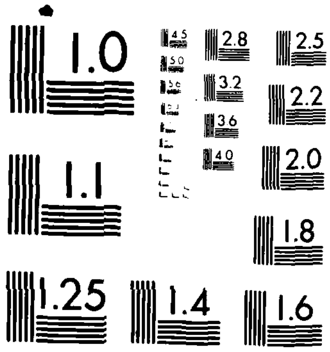

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STE. GENEVIEVE, MISSOURI FEASIBILITY REPORT

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FLOOD CONTROL STUDY FOR HISTORIC STE. GENEVIEVE — 80061

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Report addresses the feasibility of Federal participation in a flood protection project for the historic community of Ste. Genevieve, Missouri. The town was founded in the 1700's by French colonists. Much of the community has been designated a Registered National Historic Landmark. Flooding is primarily from the Mississippi River. The proposed plan includes a major levee and pump station, tributary channel widening and other features, and costs $33,580,000 at October 1984 price levels. Benefits include historic preservation and reduction in flood damages.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

STE. GENEVIEVE, MISSOURI
FEASIBILITY REPORT

FLOOD CONTROL STUDY
FOR HISTORIC STE. GENEVIEVE - 80061

VOLUME TWO

APPENDICES

June 1984

U. S. Army Corps of Engineers
St. Louis District
Lower Mississippi Valley Division

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

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PLAN FORMULATION

SECTION 1 - INTRODUCTION

This appendix provides additional detail on some background information presented in the MAIN REPORT. It also discusses the plan formulation effort in detail, including the first and second planning iterations and the development of flood damage reduction and related plans.

SECTION 2 - BACKGROUND INFORMATION

This section covers only those sections of the Main Report where additional detail has been developed. Additional detail was developed for some items in the existing conditions and the future conditions sections and is presented herein as follows.

2.1 EXISTING CONDITIONS IN THE STUDY AREA

2.1.1 Climate.

The climate in Ste. Genevieve is temperate and humid. It is slightly warmer and wetter than the climate in St. Louis which is 54 miles to the

north. Since climatological data is not available for Ste. Genevieve, the following data for St. Louis is provided. The mean annual temperature is 56° F, and the average amount of precipitation is 35.4 inches. Snowfall accumulation averages about 16 inches per year. The mid-day relative humidity is between 50 to 60 percent in the summer and about 55 to 65 percent in the winter. Because of the region's geographic location, rapid weather changes are common due to the interaction of continental polar and maritime tropical air masses.

2.1.2 Geology and Topography.

The study area lies within the Salem Plateau section of the Ozark Plateau Province, on the east flank of the Ozark Uplift and east of the St. Francois Mountains. The eastern portion of the study area lies within the Mississippi River floodplain.

The topography of the area varies from flat-lying floodplain near the Mississippi River to gently rolling to rugged hills in the western uplands. Elevations range from 360 feet NGVD where Gabouri Creek meets the Mississippi River to 900 feet NGVD on the North Gabouri Creek watershed divide in the northwest part of the study area.

Areas to the north, south, and west of Ste. Genevieve exhibit karst features such as sinkholes, joint cavities, caves, karst ponds, loosing streams, swallow holes and springs. These solution features have formed

in the Salem, St. Louis, and Ste. Genevieve formations which underlie these areas.

The bedrock underlying the study area is composed of Ordovician and Mississippian sedimentary rocks, principally limestones and occasional shales and sandstones. The 3 to 5 degree regional easterly dip exposes progressively younger geologic formations along a west to east traverse through the study area. The western part of the area is underlain by the Ordovician Plattin, Decorah, and Kimmswick formations, the Maquoketa Shale and the Thebes Sandstone. The Plattin Formation consists of hard compact gray limestone with some interbedded chert. The Decorah Formation is predominately a green shale intercollated with thin limestone beds. The Maquoketa Shale, Thebes Sandstone, and Orchard Creek Shale are thin and poorly exposed in the study area. They are composed of green shales, clay shales, and fine grained sandstone. The central and eastern parts of the study area are underlain by Mississippian limestones of the Fern Glen, Keokuk, Burlington, Wensaw, Salem, St. Louis, and Ste. Genevieve formations. These units consist primarily of fine to coarse grained limestones with varying amounts of interbedded cherts and shales. A pure $CaCo_3$ oolite bed in the Salem Limestone is the primary unit mined by the Mississippi Lime Company for use as quality lime.

The study area lies to the northeast of the east-west trending Ste. Genevieve fault zone. Displacement is greater than 1000 feet along this fault in Ste. Genevieve County.

The study area is located in the Ozark Random Source Zone. This seismotectonic zone is a region of moderate seismicity (earthquake activity). A greater seismic risk may be posed by two other zones: the Southern Illinois - Wabash Zone and the New Madrid Zone. Earthquake ground motions for this area would be similar to values determined for the nearby Kaskaskia Lock and Dam in Illinois.

2.1.3 Soils.

Modern soil surveys have been prepared for Ste. Genevieve County by the U.S. Department of Agriculture - Soil Conservation Service. Engineering interpretations for each soil unit encountered are included in these soil surveys.

The predominant soil units in the project area are Fults Silty Clay Loam, Haynie Silt Loam, Beaucoup Silty Clay Loam, Menfro Silt Loam, and Haymond Silt Loam. According to the Unified Soil Classification System these soils are classified as lean clays, silts, silty clays, clayey sands, and silty sands. These units represent deep, moderately well drained soils with generally low strengths. The primary usage of these units is the production of crops normally grown in the region, pasture, and wildlife habitat.

Due to flooding, these units have limitations for most urban uses. According to the Soil Conservation Service survey, most soil units within

the project limits have moderate to severe limitations when developed unless the soils are modified by such measures as compaction and drying.

A Corps of Engineers study of the project area revealed that enough suitable material is available for embankment construction and other engineering uses.

Much of the soils in the study area do not qualify as prime farmland due to topography, soil type, and/or frequency of flooding. The soil units that would meet the requirements for prime farmland are:

Ashton Silt Loam
Beaucoup Silty Clay Loam
Carr Fine Sand
Fults Silty Clay Loam
Haymond Silt Loam
Wabash Silty Clay
Wilber Silt Loam

In certain areas these soils would not be classified as prime farmland due to flood frequency (more than once every two years) and topography.

2.1.4 <u>Population</u>.

Population statistics for Ste. Genevieve County, in which the study area is located, indicate that the County's population has grown at an

average rate of 5.1 percent per census period since 1900. The actual rate for each census period had not exceeded 8.0 percent until the most recent census period, 1970-1980, when a rate of 18.0 percent was evidenced. The lowest actual rate, -7.5 percent, occurred from 1910-1920. Total population for Ste. Genevieve County in 1980 was 15,180.

The City of Ste. Genevieve, which is the largest in the County and thus the study area, over the same period has had an average growth rate of 13.7 percent per census period. The actual rate for each census period had not been lower than 4.0 percent until the two most recent census periods, 1960-1970 and 1970-1980, when rates of 0.6 and 0.3 percent, respectively were evidenced. The highest rates, 30.1 and 43.2 percent, occurred between 1920-1930 and 1940-1950, respectively. Total population for the City of Ste. Genevieve in 1980 was 4,727 including St. Jude Acres.

The County's racial makeup is primarily white (99.4 percent), with the balance (0.6 percent) being composed of blacks, American Indians, Chinese, Phillipinos, Koreans, Asian Indians, and others. The population gender is closely split, although females, with a median age of 31.0, do out-number males, with a median age of 28.4, by 0.7 percent. Family households are the primary living arrangements with 91.9 percent of the County population in evidence. Approximately half (48.8 percent), of the County's residents are maried with the remaining population being relatives, both young and old.

The education level of an area's population is a primary indicator of the area's economic vitality since there is a direct positive relationship between education levels and other measures of personal welfare, such as income. Ste. Genevieve County, for those 25 years of age and over, has experienced fluctuation since 1960 in the number of individuals having a high school education. There were 41.9 percent of those 25 years and over having a high school education in 1960 which rose to 53.7 percent in 1970. Currently, there are 51.3 percent of the age group who have attended 4 years of high school. The same period reflected a continuous decline in those 25 and over group having a college education, from 7.3 percent in 1960 to 6.4 percent in 1970, and finally 6.2 percent in 1980. One probable cause for this occurring is that may working age individuals leave the area to find work elsewhere and do not return.

2.1.5 Economy.

The economy of Ste. Genevieve County is comprised of five primary areas of employment: manufacturing, professional services, retail trade, agriculture, and construction. These areas in 1980 employed 34.2, 16.0, 13.9, 11.4, and 8.0 percent of the County's employed persons 16 years of age and over, respectively. The remaining 16.5 percent are employed in the areas of communications and public utilities, wholesale trade, finance/insurance and real estate, business and repair services, personal/entertainment and recreation services, and public

administration. Tourism, a vital cog in the economy of the City of Ste. Genevieve resulting from its historic nature, influences several areas of employment.

The unemployment rate for Ste. Genevieve County in February 1983 was approximately 12.7 percent with 7.6 percent being men and the remaining 5.1 percent women. This compares favorably to the rate of 16.0 for February 1982, although there are fewer individuals in the labor force today.

The median family income in Ste. Genevieve County for 1979 was $18,693. Using the implicit GNP Price Deflator to adjust the $8,020 median of 1970 to 1979 dollars, a 24.3 percent increase over the past decade, $15,041 to $18,693, occurred. Approximately 12.0 percent of these families had incomes of less than $7,500 while almost 5.4 percent had incomes of $40,000 or more. Nearly 12.0 percent of the families residing in Ste. Genevieve County had no workers in their family unit in contrast to 29.5 percent with one worker and 58.5 percent with two or more workers. Families making less than the poverty level totalled 7.7 percent of all families.

The median income in 1979 for unrelated individuals was $5,660, a 66.4 percent increase when compared to the $3,401 median of 1970. Approximately 2.3 percent of these individuals made $25,000 or more, while nearly 42.6 percent earned less than $5,000.

2.1.6 Aquatic Resources.

North and South Gabouri Creeks start in the Ozark uplands and join in the floodplain to flow into the Mississippi River. North Gabouri Creek is a narrow stream with low base flows. The upper end is probably intermittent during drought periods. The stream passes through a mixture of pasture, forest, and cropland in its upper reach and the Village of Ste. Genevieve in its lower reach. The upper portion of the stream has a cobble and gravel substrate with little instream cover. The lower stream has a mixture of bedrock, gravel, cobble and muck for substrate. Instream cover consists of a mixture of man-made and natural debris. The Missouri Department of Natural Resources (1981) investigated a fish kill on North Gabouri Creek on April 22, 1981, which resulted from the release of hog manure from a confined hog raising operation. All fish and aquatic organisms were reported within a two mile reach of the stream.

South Gabouri Creek is similar in width, base flows and riparian habitat to North Gabouri Creek. It is normally clear during low flows in its upper reach, becoming turbid during periods of runoff. The upper stream is shallow with a cobble and gravel substrate with sparse instream cover. The lower stream is shallow with a substrate comprised of gravel and limestone mining wastes. In areas of heavy waste deposits, the material is over one-foot thick and is marl-like in consistency. The stream has milky color presumably from the limestone mining wastes.

At the confluence of North and South Gabouri Creeks the stream is wide and quite deep. Water levels in this segment of stream are influenced by the Mississippi River. The water is normally turbid. Sewage effluent from nearby lagoons enters the stream at the site. The bottom substrate consists of muck. Debris at normal water levels and flooded timber at high water levels provide instream cover.

Valle Spring Branch has about two miles of defined channel, from South Gabouri Creek to Valle Spring. However, in the Valle Spring Branch watershed there are other channels that flow into sinkholes and are thought to join Valle Spring underground. There is essentially no development in the Valle Spring Branch floodplain. Most of the defined channel is essentially a drainage ditch through the flat Mississippi River floodplain.

Gabouri Creek enters the Mississippi River at river mile 122.5 above the Ohio River. Man's activities in the Middle Mississippi have severely altered the aquatic habitat. Most of the fisheries habitat can be classified as main channel and main channel boarder with the channel boarder being the more biologically productive of the two. A single Mississippi slough occurs within the project area. Sloughs are highly productive areas which serve as nursery grounds and are extremely important to the fishery.

2.1.7 Endangered and Threatened Species.

a. Federal.

The bald eagle is a winter resident that occurs along the Mississippi River feeding primarily on fish and waterfowl.

The riparian habitat in the study area is potential Indiana bat summer habitat. However, there are no known nursery colonies in the study area.

It is unlikely that either the fat pocketbook pearly mussel or Higgin's eye pearly mussel occur in the area.

b. State.

A number of state-listed plant and animal species may occur in the study area and are listed in Appendix F. There is no known important habitat for any of these species in the study area.

2.1.8 Mineral Resources.

The major mineral commodities of the area are lime, crushed stone, building stone and sand and gravel. The only lime producer in the county and the largest in the State is the Mississippi Lime Company. This

operation produces both quicklime and hydrated lime from the relatively pure $CaCo_3$ oolite beds in the Salem Limestone. The plant utilizes rotary and vertical kilns to produce about 5,000 tons of quality lime daily. The underground mining of this limestone unit has progressed down-dip to a maximum depth of nearly 200 feet below the surface. This operation has resulted in the undermining of a large area (greater than 1,500 acres) immediately west of Ste. Genevieve. In addition to lime production, limestone is also quarried for use as crushed stone and building stone. One of the largest limestone quarries in the area is the Tower Rock Stone Company quarry located north of Ste. Genevieve. The stone from this quarry is extracted from the Salem Limestone. A few smaller limestone quarries are also located in the county, however, most of these are currently idle. Limestone "marble" has been produced in the past, however, these operations are presently inactive.

Sand and gravel workings are located on the Mississippi River floodplain and in the upland tributary streambeds. Many of these deposits are worked intermittently as required by construction demand. The nearest sand operation is approximately three miles south of Ste. Genevieve, adjacent to the site of the old village.

Copper deposits were mined in the Cornwall mine area in Ste. Genevieve County sporadically from 1863 to 1916. These deposits were near-surface occurrences that were easily exploitable. Although similar concentrations of copper minerals may exist down-dip from these old

workings the costs of exploration and development limits their potential for the foreseeable future.

2.1.9 Water Supply.

The major source of water in the area is derived from unconfined aquifers in the Mississippi River Recent alluvium. The Ste. Genevieve municipal water system and various private users draw from these shallow, high yield wells in the floodplain sands and gravels. West of the floodplain some private wells penetrate bedrock aquifers, however, yields are generally low and depths to reliable supplies are often excessive (up to 1,200 feet to St. Peter Sandstone). The shallower bedrock wells in many cases intercept water bearing solution joints and fractures. Seasonally the water levels in these shallow wells can vary greatly because of the low bulk fracture porosity of these limestones. In addition, near surface groundwater associated with solution fractures is particularly susceptible to pollution from surface recharge.

The Ste. Genevieve municipal water system is supplied by four wells having a combined capacity of approximately 1725 gallons per minute. The fourth well was recently added to handle additional demand due to projected future growth. The wells are close to each other and are located east of the St. Louis and San Francisco Railroad and between Merchant Street and Market Street. The wells produce good quality water requiring only softening, except for the fourth well which also requires magnesium removal.

The system services a total of 1789 customers in and around the municipality and has a total capacity of 1.2 million gallons per day. The average daily consumption rate is 650,000 gallons per day, or an average of 363 gallons per customer per day.

The City has a finished water storage capacity of 650,000 gallons maintained in two standpipes and a water tank. Presently, much of the City is served by mains that are 4 inches in diameter or less, maintaining an approximate water pressure of 40 pounds per square inch.

The municipal water wells have never been inundated by a flood. The 1973 flood reached 17 inches below the top of the wells. Subsequently, the wells were raised 40 inches, so that the tops of the casings are now 57 inches above the 1973 flood height. The new well casings' elevations are approximately 395 feet NGVD, which is about one half foot higher than the 100-year flood.

2.1.10 Wastewater Collection and Treatment.

The sewerage system of the City of Ste. Genevieve, presently serves the incorporated area of the city. The system consists of an extensive sewage collection network, two lift stations, and a two-cell lagoon.

Approximately 30 miles of sewers, ranging in size from 4 to 15 inches in diameter, and 250 concrete and brick manholes, collect and transport an average of 650,000 qpd (dry weather flow) to one of the two lift

stations. One lift station is located at Front and Market Streets and the other at North Main and Riverview Drive. The sewage is then pumped through a 10-inch cast iron pipe to the two cell lagoon for treatment. The lagoon consists of a primary and secondary cell surrounded by a berm. The berm has an approximate elevation of 385$\pm$, providing a flood frequency protection for the lagoon. The treated effluent from the lagoon is then discharged into the Mississippi River.

Currently, the sewage lagoon is not operating at full capacity due to extensive damage incurred from the December 1982 flood. The 10-inch pressure sewer line experienced a break prior to discharge into the lagoon. As a result, the influent was discharged into the surrounding floodplain floodwaters. Also, the berm on the west end of the primary cell received considerable damage due to the scour and wave action of the floodwaters. Again, the sewage contained within the lagoon drained out into the surrounding floodplain. The untreated sewage in the floodplain created a health hazard requiring immediate attention.

The repairs and solutions to the sewage lagoon are as follows: The 10-inch pressure sewer was repaired and is temporarily discharging into the secondary cell instead of the primary cell. The repair of the primary cell is contingent upon a feasibility report being done by the city engineer. The report will recommend either repair and reconstruction of the existing sewage lagoon or a new treatment facility. The new facility would be able to meet EPA effluent

regulations, contrary to the existing system. Also, the new facility would be located at a higher elevation providing better flood protection. The recommendations will be based upon the funds available from FEMA and the State of Missouri due to damages incurred from the floods.

2.2 FUTURE CONDITIONS IN THE STUDY AREA WITHOUT CORPS PROJECT

2.2.1 Population.

Population projections for the Ste. Genevieve area are based on 1980 OBERS data for the NON-SMSA Part of Bureau of Economic Affairs Economic Area 107: St. Louis , Missouri (MO Part). The OBERS projections, with no change in the share of population, indicate approximate increases in population of 3.1 percent from 1980 to 1990 and 2.3 percent for each succeeding decade through the year 2030. The total population projected for Ste. Genevieve County then becomes 15,651 for 1990, 16,011 for the year 2000, and finally 17,141 for 2030. The City of Ste. Genevieve's population is projected to be 4,874 for 1990, 4,986 for the year 2000, and finally 5,338 for 2030. Due to Ste. Genevieve County's close proximity to the St. Louis Standard Metropolitan Statistical Area, the rates of increase may be slightly higher.

The County and City racial and gender makeup should not change significantly over time. Family households will continue to be the primary living arrangements in the area.

The number of individuals in Ste. Genevieve County, 25 years of age and over, having a high school education will continue to fluctuate. The degree of fluctuation will depend primarily on the number of graduates entering the labor force, the willingness of graduates to commute to other job markets, the availability of local employment opportunities, and the educational history of current non-residents relocating to the area. The number of residents 25 years of age and over having a college degree will probably continue to decline slightly as new graduates leave the area to find work elsewhere.

2.2.2 Economy.

Two of the current five primary areas of employment for Ste. Genevieve County, namely professional services and retail trade, are projected to increase their number of employees through the year 2030. The number of individuals working in manufacturing and construction is projected to increase through 1990 and 2010, respectively. Agricultural employment will continue to decrease. These increases and decreases reflect minor changes in the total number of jobs available.

Median family income, $18,693 for 1979, using OBERS Projections will be approximately $23,404 in 1990, $28,857 in the year 2000, and finally $55,232 in 2030. The median unrelated individual's income should approximate $7,086 in 1990, $8,737 in the year 2000, and $16,723 by 2030.

The unemployment outlook is uncertain in that it will depend upon several factors. Some of these factors are the availability of local employment opportunities, the willingness of individuals in the labor force to commute to other job market areas, and the number of individuals leaving the local labor force and relocating to find jobs elsewhere.

The overall economic outlook for Ste. Genevieve is one of little change. The City of Ste. Genevieve is somewhat restricted in that it can only grow westward. Though tourists are attracted to the City's historic resources, frequent flooding make is it increasingly more difficult to improve the area and maximize the tourism opportunities. Many individuals are unable to find jobs and thus leave the area for this reason. There are no major indicators that the job market will change significantly in the future.

SECTION 3 - FORMULATION AND EVALUATION OF PLANS

3.1 FLOOD DAMAGE REDUCTION AND RELATED MEASURES

3.1.1 Types of Measures Considered.

During the course of the Ste. Genevieve study many flood damage reduction measures were considered. The measures were subjected to a screening process that included such factors as the effect of the measure on cultural resources, cost relative to other measures that would have

similar flood damage reduction effects, engineering feasibility, local acceptance, hydraulics effects, level of protection, environmental effects and others. Some measures were screened out relatively quickly and others were carried into the detailed design and evaluation stage.

Both structural and non-structural flood damage reduction measures were considered. Structural measures included levees; floodwalls; interior drainage features such as pump stations, gravity drains, ditching, and channel relocation; detention dams and reservoirs; diversions; channel enlargement; clearing and snagging; bridge replacement; and improvement of the hydraulic efficiency of bridges. Non-structural measures included demolition of building, relocation of buildings, floodproofing, and raising the elevation of buildings, and small levees.

The Ste. Genevieve study included a preliminary examination of detention dams and reservoirs, five in the North Gabouri Creek watershed and two in the South Gabouri drainage area. The detention sites were determined to be infeasible for the following reasons: dams and reservoirs above urban areas are designed by the Corps of Engineers to be highly stable and safe and are generally very costly, foundations and seepage problems would result from Karst topography in the area, the Mississippi Lime Company mine underlies a significant part of the area, the two detention sites on tributaries of South Gabouri Creek are a long distance from the flood damage problem area, and a relatively low level

of economic and historical benefits would be expected to result from the detention sites on either stream.

Major diversions of the high flows from North and South Gabouri Creeks through tunnels to the north and south limits of the study area, respectively, could reduce flooding along these streams and reduce pumping and other interior drainage costs for some levee plans. However, major tunnel diversions were determined to be infeasible because of high costs, Karst topography, and the extensive Mississippi Lime Company mine. A channel diversion of Valle Spring Branch in the Mississippi River floodplain is included in two of the measures developed in detail. Minor channel diversions are included in some measures.

The non-structural measures found to be engineeringly feasible in the Ste. Genevieve area were demolition of structures, relocation of structures or contents, raising the first floor elevation of structures, and floodproofing commercial structures. Floodproofing of residential buildings by making the structure water tight was found to be impractical because of saturated ground, long term flooding, old foundations, and old and often frame structures. During floods basements often fill with water, or are pumped, even if the surface water is several hundred feet away from the building. The ground becomes saturated and water sometimes pours into the basements through rock foundation walls and dirt floors.

The Ste. Genevieve study developed flood damage reduction measures during two planning iterations. The measures are independent in the sense that they would provide a level of flood protection for certain areas. The first iteration measures were developed by the St. Louis District in an effort to reanalyze flood control plans developed by the Corps of Engineers in the 1970's. The second iteration plans were the result of local comments on the findings of the Corps first iteration study.

3.1.2 First Iteration.

a. No Corps Action.

Ste. Genevieve will continue to be flooded if no Corps of Engineer project is implemented as a result of this study. The town will continue to fight the Mississippi River floods with sandbag and other levees, relocation of movable items, and other efforts. Damages will be reduced as a result of the flood fights but heavy damages will still be sustained. Floods higher than the 1973 flood (30-year flood) could well overtop the flood fight levees and result in much more destruction.

Local efforts to control floods on North and South Gabouri Creeks may include occasional channel cleanout on both streams. Levees left in place after Mississippi River flood fight efforts will reduce damages from flash flooding on North Gabouri Creek if closures are made. Over the next 100 years it is probable that several bridges over the tributary

streams will be replaced with structures that are less of an impediment to flood flows.

b. Levee/Floodwall Measures.

Eight levee/floodwall measures were developed during the first iteration of the planning process. Each levee/floodwall was designed at three heights or levels of protection as shown below:

Height	Mississippi River Levee	Flank Levees Along Tributaries
(1)	1973 Mississippi River flood (30 year), with 3 feet of freeboard.	50-year tributary flood coincident with 1973 Mississippi River flood, with 3 feet of freeboard.
(2)	100-year Mississippi River flood, with 3 feet of freeboard.	100-year tributary flood coincident with 100-year Mississippi River flood, with 3 feet of freeboard.
(3)	Urban Design Flood (UDF is comparable to 500-year flood) on Mississippi River, with 3 feet of freeboard.	Standard Project Flood (SPF) on tributary coincident with UDF on Mississippi River, with 3 feet of freeboard.

Measures 1, 2, 3 and 4 were located close in to the community and flanked the tributary streams. The alignments of these measures are shown on PLATES A-1, A-2, A-3 and A-4. Measures 5, 6, 7 and 8 are located away from the town out on the Mississippi River floodplain. In addition to designing three heights, the levee parts of Measures 5, 6, 7 and 8 were also designed for two construction techniques. In one design, the levees would be constructed with impervious soil borrowed from the

adjacent floodplain lands. The other design involved levee construction using material dredged from the Mississippi River and a cap of impervious soil taken from adjacent lands. The alignments and other features of these measures are shown on PLATES A-5, A-6, A-7 and A-8. The plates show the land taken by the highest and largest of the three levee sizes and the borrow area needed for this large levee with the dredged material design. The location and size of the borrow areas may be modified based on post authorization soil borings and analysis.

c. Nonstructural Measures.

Measure 20 involves either relocation or demolition of structures that are flooded above the first floor by the 10-year Mississippi River flood or the 10-year flood on North or South Gabouri Creek. Buildings would be relocated if (1) relocation is economically advantageous, (2) the building is a significant historic structure that can be moved, or (3) it is a mobile home. Measure 20 includes relocation of 10 and demolition of 23 structures and is shown on PLATE A-9.

Measure 21 addresses historic structures only. It involves relocation of those buildings identified by the 1969 Ste. Genevieve Landmarks Commission survey, and additional French colonial homes identified later, that would have been flooded by surface water during the April 1973 flood if no emergency levee protection had been provided. This flooding could be above or below the first floor. Measures 21

includes relocation of 16 historic structures to flood free sites and is shown on PLATE A-10.

It should be noted that during the second planning iteration, errors were found in some first floor elevations and additional structures were classified as historical by the University of Missouri. These two factors would probably change the selection of buildings included in Measures 20 and 21. However, as will be seen later, Measures 20 and 21 were eliminated from consideration at the end of the first iteration and, therefore, were not updated when more accurate data became available during the second iteration.

d. Recreation Measure.

In the first planning iteration a maximized recreation measure called Measure 15 was developed. The concept was to develop a maximum amount of recreation features that could be associated with flood damage reduction measures. These features could be scaled down later and be made compatible with a selected flood damage reduction plan. Measure 15 included land along North Gabouri Creek, one parcel of land adjacent to South Gabouri Creek, trails along the tributaries and the levees, facilities for group recreation activities, and use of borrow areas for nature study. In the first iteration recreation was formulated under Principals and Standards. The recreation value used was $1.00/visitor day. See APPENDIX G - RECREATION.

e. Evaluation of First Iteration Measures.

(1) Level of Protection.

First iteration measures were designed to provide a variety of levels of protection. Levee and floodwall measures were analyzed at three heights as was discussed previously under Levee/Floodwall Measures. The first iteration interior drainage analyses were preliminary in detail. Interior drainage systems were designed to keep the 10 year 48 hour rainfall from ponding to the point where urban damages would begin to occur. The two non-structural measures were designed to prevent some of the damages from the 10-year Mississippi River and Gabouri Creek floods, and from the 1973 Mississippi River flood (30-year). The levels of protection provided by the first iteration measures are shown in TABLE A-1.

(2) Costs.

Cost estimates for the first iteration measures were developed in October 1982 dollars, and annual interest and amortization costs were determined using a 7-7/8% interest rate. Information on the cost estimates is presented in APPENDIX D - DESIGN AND COST ESTIMATES. The total costs and annual costs for the first iteration measures are shown in TABLE A-2.

TABLE A-1
Levels of Protection
Provided By First Iteration Measures

	From Mississippi River Flood In Average Recurrence Interval (Years)	By Flank Levees Protecting From Gabouri Cr. Flooding in Avg. Rec. Int. (Years)	From North and South Gabouri Creek Flooding in Avg. Rec. Int. (Years)	From Ponding Interior Drainage Assuming Blocked Gravity Drains Avg. Rec. Int. (Years)
Measure 1 Levee	30,100,500 (UDF)	50,100 (SPF)	1	10
Measure 2 Levee/Floodwall	30,100,500 (UDF)	50,100 (SPF)	1	10
Measure 3 Levee/Floodwall	30,100,500 (UDF)	50,100 (SPF)	1	10
Measure 4 Levee/Floodwall	30,100,500 (UDF)	50,100 (SPF)	1	10
Measure 5 Levee/Floodwall	30,100,500 (UDF)	50,100 (SPF)	1	10
Measure 6 Levee	30,100,500 (UDF)	Not Applicable	1	10
Measure 7 Levee/Floodwall	30,100,500 (UDF)	50,100 (SPF)	1	10
Measure 8 Levee	30,100,500 (UDF)	Not Applicable	1	10
Measure 15 Recreation	Not Applicable	Not Applicable	N.A.	N.A.
Measure 20 Relocation/ Demolition	Total Protection For 33 buildings. 10-year protection for remaining floodprone buildings with residual basement damages.	Not Applicable	Total Protection For 33 Buildings. 10-year protection for remaining floodprone buildings with residual basement damages.	N.A.
Measure 21 Relocation Historic Bldgs.	Total Protection For 16 buildings. 2-year protection for remaining floodprone buildings.	Not Applicable	Total Protection For 16 Building. 1-year protection for remaining floodprone buildings.	N.A.

TABLE A-2
COSTS OF FIRST ITERATION MEASURES
OCTOBER 1982 PRICE LEVEL

			Total First Cost ($1000)	Annual Int & Amort @ 7-7/8% ($1000)[2]	Annual Operation & Maint ($1000)	Annual Replacement Cost ($1000)	Total Annual Cost ($1000)
Measure 1	30 year	Soil	6,340	538	18	16	572
Levee	100 year	Soil	7,126	605	19	17	641
	500 year	Soil	8,143	693	20	17	730
Measure 2	30 year	Soil	8,316	707	18	23	748
Levee/	100 year	Soil	9,990	849	22	25	896
Floodwall	500 year	Soil	12,228	1,039	26	28	1,093
Measure 3	30 year	Soil	7,566	644	17	19	680
Levee/	100 year	Soil	9,638	819	20	23	862
Floodwall	500 year	Soil	11,922	1,014	23	25	1,062
Measure 4	30 year	Soil	7,255	617	13	25	654
Levee/	100 year	Soil	9,319	792	16	27	835
Floodwall	500 year	Soil	12,580	1,069	21	31	1,121
Measure 5	30 year	Soil	12,201	999	28	19	1,046
Levee/		Soil/D.M.[1]	10,937	896	28	19	943
Floodwall	100 year	Soil	15,945	1,306	31	20	1,357
		Soil/D.M.	14,359	1,176	31	20	1,227
	500 year	Soil	18,403	1,507	34	22	1,563
		Soil/D.M.	17,788	1,457	34	22	1,513
Measure 6	30 year	Soil	17,336	1,420	40	22	1,482
Levee/		Soil/D.M.	15,612	1,279	40	22	1,341
	100 year	Soil	21,570	1,766	44	23	1,833
		Soil/D.M.	19,555	1,601	44	23	1,668
	500 year	Soil	24,993	2,046	48	25	2,119
		Soil/D.M.	23,099	1,891	48	25	1,964

TABLE A-2 (Cont'd)
COSTS OF FIRST ITERATION MEASURES
OCTOBER 1982 PRICE LEVEL

			Total First Cost ($1000)	Annual Int & Amort @ 7-7/8% ($1000)	Annual Operation & Maint ($1000)	Annual Replacement Cost ($1000)	Total Annual Cost ($1000)
Measure 7	30 year	Soil	11,633	953	20	38	1,011
Levee/		Soil/D.M.	10,845	888	20	38	946
Floodwall	100 year	Soil	13,981	1,145	23	40	1,208
		Soil/D.M.	13,066	1,070	23	40	1,133
	500 year	Soil	16,220	1,327	26	42	1,395
		Soil/D.M.	15,214	1,245	26	42	1,313
Measure 8	30 year	Soil	17,965	1,471	33	51	1,555
Levee/		Soil/D.M.	16,223	1,329	33	51	1,413
	100 year	Soil	20,764	1,699	37	53	1,789
		Soil/D.M.	20,334	1,664	37	53	1,754
	500 year	Soil	23,336	1,911	40	54	2,005
		Soil/D.M.	22,851	1,871	40	54	1,965
Measure 15 Recreation			541	43	4	1	48
Measure 20 Relocation (10 Structures) Demolition (23 Structures)			2,364	186	0	0	186
Measure 21 Relocation (16 Structures)			2,286	180	N/A	N/A	180

1/ Soil/D.M. is dredged material covered with a cap of impervious soil.

2/ Includes interest during construction.

(3) Economic and Recreation Benefits.

All the first iteration flood damage reduction measures achieve benefits in the urban part of the study area. Some also produce agricultural benefits. The measures achieve benefits by reducing annual damages in the Ste. Genevieve, but, of course, there are residual damages associated with each measure.

The first iteration recreation measure also produces annual dollar benefits. These benefits are based on projected annual user days associated with the recreation features of the measure.

A summary of economic benefits, residual damages and recreation benefits resulting from the first iteration measures is presented in TABLE A-3. Additional detail on these benefits is presented in APPENDIX G - RECREATION and APPENDIX H - ECONOMICS.

(4) Cultural Resources Effects.

All of the first iteration measures achieve cultural benefits by protecting various historic homes from flooding. However, Measures 1 through 4, 20, and 21 adversely affect the historic resource because of visual impacts or physical harm to historic buildings or the historic setting. The 100-year and 500-year versions of Measures 5 and 7 also adversely affect the historic resource. Measures 6 and 8 provide flood

TABLE A-3
ECONOMIC AND RECREATION BENEFITS
FROM FIRST ITERATION MEASURES

			Annual Urban Benefits ($1000)	Annual Agricultural Benefits ($1000)	Annual Residual Flood Damages ($1000)	Annual Recreation Benefits ($1000)	Total Annual Benefits (1)+(2)+(4) ($1000)
Measure 1	30 year	Soil	27	0	431	0	27
Levee	100 year	Soil	31	0	427	0	31
	500 year	Soil	35	0	423	0	35
Measure 2	30 year	Soil	118	0	340	0	118
Levee/	100 year	Soil	198	0	260	0	198
Floodwall	500 year	Soil	235	0	223	0	235
Measure 3	30 year	Soil	29	0	429	0	29
Levee/	100 year	Soil	57	0	401	0	57
Floodwall	500 year	Soil	78	0	380	0	78
Measure 4	30 year	Soil	78	0	380	0	78
Levee/	100 year	Soil	136	0	322	0	136
Floodwall	500 year	Soil	163	0	295	0	163
Measure 5	30 year	Soil	122	11	325	0	133
Levee/		Soil/D.M.[1/]	122	11	325	0	133
Floodwall	100 year	Soil	227	11	220	0	238
		Soil/D.M.	227	13	218	0	240
	500 year	Soil	284	8	166	0	292
		Soil/D.M.	284	13	161	0	297
Measure 6	30 year	Soil	125	23	310	0	148
Levee/		Soil/D.M.	125	25	308	0	150
	100 year	Soil	234	17	206	0	251
		Soil/D.M.	234	27	197	0	261
	500 year	Soil	298	19	141	0	317
		Soil/D.M.	298	29	131	0	327

TABLE A-3 (Cont'd)
ECONOMIC AND RECREATION BENEFITS
FROM FIRST ITERATION MEASURES

			Annual Urban Benefits ($1000)	Annual Agricultural Benefits ($1000)	Annual Residual Flood Damages ($1000)	Annual Recreation Benefits ($1000)	Total Annual Benefits (1)+(2)+(4) ($1000)
Measure 7	30 year	Soil	122	3	333	0	125
Levee/		Soil/D.M.	122	2	334	0	124
Floodwall	100 year	Soil	227	3	228	0	230
		Soil/D.M.	227	5	226	0	232
	500 year	Soil	284	2	171	0	286
		Soil/D.M.	284	6	168	0	290
Measure 8	30 year	Soil	125	18	316	0	143
Levee/		Soil/D.M.	125	19	315	0	144
	100 year	Soil	234	19	205	0	253
		Soil/D.M.	234	20	204	0	254
	500 year	Soil	298	17	143	0	315
		Soil/D.M.	298	20	140	0	318
Measure 15 Recreation			0	0	0	57	57
Measure 20 Relocation (10 Structures) Demolition (23 Structures)			83	0	375	0	83
Measure 21 Relocation (16 Structures)			9	0	449	0	9

1/ Soil/D.M. is dredged material covered with a cap of impervious soil.

protection and do not adversely affect the historical resource. A summary of the effects of the measures on cultural resources is presented in TABLE A-4. Additional detail is provided in APPENDIX E - CULTURAL RESOURCES.

(5) Ecological Effects.

A summary of the ecological effects of the first iteration measures is presented in TABLE A-5. Additional detail is presented in APPENDIX F - ECOLOGICAL RESOURCES.

(6) Summary of Evaluation of First Iteration Measures.

The first iteration measures were evaluated on the basis of costs, economic and recreation benefits, level of protection, ecological effects, and cultural resources effects. A summary of the evaluation is given in TABLE A-6.

As can be seen in TABLE 6, none of the first iteration flood damage reduction measures were economically justified. There was therefore no opportunity to select an economically optimum measure, and the decision on which measures to carry into the second iteration was based on level of protection, the effects of the measures on cultural resources, and public involvement.

TABLE A-4
Summary of Effects on Cultural Resources
First Iteration Measures

	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8	Measure 20	Measure 21
Surviving historic buildings	Protects 6; leaves 78 unprotected; channelization adversely affects 3.	Protects 38; leaves 45 unprotected; levee adversely affects 3.	Protects 7; leaves 72 unprotected; levee adversely affects 7.	Protects 37; leaves 47 unprotected; levee adversely affects 2.	Protects 46; leaves 36 unprotected; levee adversely affects 4.	Protects 85; leaves 1 unprotected; levee adversely affects none.	Protects 45; leaves 37 unprotected; levee adversely affects 4.	Protects 84; leaves 2 unprotected; levee adversely affects none.	Protects 5; leaves 82 unprotected from floods greater than 10-year events.	Protects 16; leaves 71 unprotected from greater than 30-year events.
Spatial, chronological and architectural associations of historic district	Adversely affects entire district by isolating a portion of it.	Same as Measure 1, though more severe.	Same as Measure 1, though more severe.	Same as Measure 1, though more severe.	Same as Measure 1, though less severe.	No adverse effect, isolates only one structure.	Same as Measure 5.	Same as Measure 6.	Adversely affects entire district by relocation/demolition.	Same as Measure 20, though more severe.
Visual and aesthetic character	Levee introduces out-of-character visual element and isolates a portion of the district from Common Fields.	Levee and floodwalls introduce out-of-character visual elements to large portion of the district.	Same as Measures 1, and 2.	Same as Measure 2, though more severe.	Same as Measure 2, though less severe.	No adverse effect, indirect beneficial effect highly likely.	Same as Measure 5.	Same as Measure 6.	Adversely affects district by isolating portions of it.	Same as Measure 20, though more severe.
Distinctive characteristics of historic buildings	Direct adverse effect to 3 buildings.	Direct adverse effect to 3 buildings.	Direct adverse effect to 7 buildings.	Direct adverse effect to 2 buildings.	Direct adverse effect to 4 buildings.	No effect, indirect beneficial effect highly likely.	Same as Measure 5.	Same as Measure 6.	Moderate likelihood of indirect adverse effect to relocated buildings.	Same as Measure 20, though more severe.

TABLE A-4 (Cont'd)
Summary of Effects on Cultural Resources
First Iteration Measures

	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8	Measure 20	Measure 21
Community significance	Diminished by visual effects and by direct adverse effect to buildings.	Same as Measure 1, though more severe.	Same as Measure 1, though more severe.	Same as Measure 1, though more severe.	Same as Measure 1, though more severe.	No effect, indirect beneficial effect highly likely.	Same as Measure 5.	Same as Measure 6.	Diminished by removal of buildings from historic setting.	Same as Measure 20, though adverse impact extreme.
Archaeological resources	Very likely to affect archaeological sites.	Moderately likely to affect archaeological sites.	Same as Measure 2.	Slight possibility of affecting archaeological sites.	Very likely to affect affect archaeological sites.	Moderately likely to affect archaeological sites.	Same as Measure 5.	Same as Measure 6.	Slight possibility of information loss at building sites.	Same as Measure 20.

TABLE A-5
Summary of Ecological Impacts
First Iteration Measures

Ecological Resources	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8	Measures 20 and 21
Farmland	Loss of 27.2 to 53.4 ac	Loss of 16.9 to 42.9 ac	Loss of 23.6 to 53.6 ac	Loss of 4.5 to 12.3 ac	Loss of 142.5 to 324.6 ac Floodplain used for ponding area	Loss of 313.7 to 646.4 ac Floodplain used for ponding area	Loss of 89.9 to 235.5 ac Floodplain used for ponding area	Loss of 269.7 to 527.8 ac Floodplain used for ponding area	NSI
Wetlands	Gain of 17.9 to 38.3 ac	Gain of 13.2 to 34.0 ac	Gain of 14.2 to 12.3 ac	Gain of 4.5 to 12.3 ac	Gain of 34.3 to 201.7 ac	Gain of 59.3 to 382.1 ac	Gain of 34.0 to 165.0 ac	Gain of 45.4 to 286.0 ac	NSI
Groundwater	NSI	Several existing water wells will be relocated to accommodate the levee	NSI	NSI	NSI	NSI	NSI	NSI	NSI
Water Quality	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI
Endangered Species	Net gain of 300 ft. riparian Indiana bat summer habitat and 2 state listed plants	Minor increase for 2 state listed plants	Minor increase for 2 state listed plants	Minor increase for 2 state listed plants	Net loss of 200 ft. of riparian Indiana bat summer habitat. Moderate increase for 2 state listed plants	Net gain of 4800 ft. of riparian Indiana bat summer habitat and 2 state listed plants	Net loss of 200 ft. of riparian Indiana bat summer habitat. Moderate increase for 2 state listed plants	Net gain of 4800 ft. of riparian Indiana bat summer habitat and 2 state listed plants	NSI
Floodplain Forest	Loss of 0.5 to 1.0 ac	Loss of 0.1 ac	Loss of 1.2 ac	NSI	Loss of 8.5 to 12.9 ac	Loss of 4.6 to 8.8 ac	Loss of 5.2 to 6.8 ac	Loss of 1.7 to 2.6 ac	NSI

TABLE A-5 (Cont'd)
Summary of Ecological Impacts
First Iteration Measures

Ecological Resources	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8	Measures 20 and 21
Aquatic Resources	NSI	NSI	NSI	NSI	Minor adverse impact due to loss of 3000 ft. of stream	Minor adverse impact due to loss of 800 ft. of stream and cutoff of Miss. slough	Minor adverse impact due to loss of 3000 ft. of stream	Minor adverse impact due to loss of 800 ft. of stream	NSI
Terrestrial Resources	Minor increase for wetland species	Minor increase for wetland species	Minor increase for wetland species	Minor increase for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	NSI
Aesthetics	Moderate adverse impact along St. Marys Road	Major adverse impact to center of town	Major adverse impact to North Gabouri Creek	Major adverse impact to center of town	Moderate adverse impact along South Gabouri Creek	NSI	Moderate adverse impact along South Gabouri Creek	Moderate adverse impact along South Gabouri Creek	Moderate beneficial impact
Sewage Treatment Plant	NSI	NSI	NSI	NSI	NSI	Flood protection afforded	NSI	NSI	NSI
Water Treatment Plant	NSI	Flood protection afforded	NSI	NSI	Flood protection afforded	Flood protection afforded	Flood protection afforded	Flood protection afforded	NSI

TABLE A-6
SUMMARY OF EVALUATION
OF FIRST ITERATION MEASURES

			Total First Cost[2] ($1000)	Total Annual Benefits ($1000)	Total Annual Costs ($1000)	Benefit/ Cost Ratio	Level of Protection Relative to Av. Levee[3]	Effect on Ecology (+-Scale)[4]	Effect on Cultural Resources (Type)[5]
Measure 1	30 year	Soil	6,340	27	572	.05	-	0	Type 2
Levee	100 year	Soil	7,126	31	641	.05	+	0	Type 2
	500 year	Soil	8,143	35	730	.05	+	0	Type 2
Measure 2	30 year	Soil	8,316	118	748	.16	-	0	Type 2
Levee/	100 year	Soil	9,990	199	896	.22	+	0	Type 2
Floodwall	500 year	Soil	12,228	236	1,093	.22	+	0	Type 2
Measure 3	30 year	Soil	7,566	29	680	.04	-	0	Type 2
Levee/	100 year	Soil	9,638	57	862	.07	+	0	Type 2
Floodwall	500 year	Soil	11,922	78	1,062	.07	+	0	Type 2
Measure 4	30 year	Soil	7,255	78	654	.12	-	0	Type 2
Levee/	100 year	Soil	9,319	136	835	.16	+	0	Type 2
Floodwall	500 year	Soil	12,580	163	1,121	.15	+	0	Type 2
Measure 5	30 year	Soil	12,201	133	1,046	.13	-	0	Type 1
Levee/		Soil/D.M.[1]	10,937	133	943	.14	-	0	Type 1
Floodwall	100 year	Soil	15,945	238	1,357	.18	+	0	Type 2
		Soil/D.M.	14,359	240	1,227	.20	+	0	Type 2
	500 year	Soil	18,403	292	1,563	.19	+	0	Type 2
		Soil/D.M.	17,788	297	1,513	.20	+	0	Type 2
Measure 6	30 year	Soil	17,336	148	1,482	.10	-	0	Type 1
Levee/		Soil/D.M.	15,612	150	1,341	.11	-	0	Type 1
	100 year	Soil	21,570	252	1,833	.14	+	0	Type 1
		Soil/D.M.	19,555	261	1,668	.16	+	0	Type 1
	500 year	Soil	24,993	317	2,119	.15	+	+1	Type 1
		Soil/D.M.	23,099	327	1,964	.17	+	0	Type 1
Measure 7	30 year	Soil	11,633	125	1,011	.12	-	0	Type 1
Levee/		Soil/D.M.	10,845	124	946	.13	-	0	Type 1
Floodwall	100 year	Soil	13,981	230	1,208	.19	+	0	Type 2
		Soil/D.M.	13,066	232	1,133	.20	+	0	Type 2
	500 year	Soil	16,220	287	1,395	.21	+	0	Type 2
		Soil/D.M.	15,214	290	1,313	.22	+	0	Type 2

TABLE A-6 (Cont'd)
SUMMARY OF EVALUATION
OF FIRST ITERATION MEASURES

			Total First Cost[2] ($1000)	Total Annual Benefits ($1000)	Total Annual Costs ($1000)	Benefit/ Cost Ratio	Level of Protection Relative to Ag. Levee[3]	Effect on Ecology (+-Scale)[4]	Effect on Cultural Resources (Type)[5]
Measure 8 Levee/	30 year	Soil	17,965	142	1,555	.09	-	0	Type 1
		Soil/D.M.	16,223	143	1,413	.10	-	0	Type 1
	100 year	Soil	20,764	253	1,789	.14	+	0	Type 1
		Soil/D.M.	20,334	254	1,754	.14	+	0	Type 1
	500 year	Soil	23,336	315	2,005	.16	+	0	Type 1
		Soil/D.M.	22,851	318	1,965	.16	+	0	Type 1
Measure 15 Recreation			541	56	48	1.17	N/A	+1	N/A
Measure 20 Relocation (10 Structures) Demolition (23 Structures)			2,364	83	186	.45	-	0	Type 3
Measure 21 Relocation (16 Structures)			2,286	9	180	.05	-	0	Type 3
No Action			0	N/A	N/A	N/A	N/A	0	Type 3

1/ Soil/D.M. is dredged material covered with a cap of impervious soil.
2/ October 1982 price level.
3/ (-) indicates levee is lower than Federal agricultural levees and (+) indicates it is higher.
4/ (+-scale) is explained in APPENDIX F - ECOLOGICAL RESOURCES
5/ Type 1=overall beneficial effect, where measure accomplishes significant flood protection in a manner compatible with cultural resources; Type 2=overall adverse effect, where measures accomplish flood protection but directly cause adverse effect to cultural resource; Type 3=measures which directly cause adverse effect to cultural resource and/or leave numerous historic buildings susceptible to frequent floods.

The appropriate level of protection for the levee/floodwall measures designed to protect Ste. Genevieve from Mississippi River flooding was determined to be the Urban Design Flood (UDF) with 3 feet of freeboard. The Urban Design Flood is comparable to the 500-year flood. This decision was based in part on the established Corps of Engineers' goal of providing a high level of protection where damages from a large flood would result in a catastrophe. Past floods in Ste. Genevieve have been devastating. Still larger floods would certainly be catastrophic. The Corps of Engineers considers the goal of providing a high level of protection to be particularly appropriate for high levees/floodwalls such as those being considered for Ste. Genevieve. The Urban Design Flood is also considered to be appropriate for Ste. Genevieve because this level of protection has been provided in all the high levee/floodwall projects build for urban areas along the Mississippi River in the St. Louis District. UDF protection for Ste. Genevieve would also be significantly higher than the Federal levee protection provided for the Prairie du Rocher agricultural area across the Mississippi River.

The ecological effects of the first iteration measures were found to be minor and did not significantly influence the decision process.

The cultural resources evaluation was conducted following the regulations of the Advisory Council for Historic Preservation. A cultural resource effect assessment was conducted for each measure and the no action alternative. The no action alternative resulted in an adverse effect because it would constitute "neglect of a property resulting in deterioration or destruction." The findings of the evaluation were that

two levee measures, Measures 6 and 8, had overall beneficial effects on cultural resources. These measures would protect the historic buildings from Mississippi River flooding and not have an adverse effect on the historic setting. Some flood damage reduction measures had severe adverse effects on the historic setting.

The conclusion of the first planning iteration was to carry forward Measures 6 and 8 and the recreation measure, and conduct more detailed studies after discussions with non-Federal interests. The levees would only be examined at the Urban Design Flood level of protection. Preliminary designs showed that levee construction with dredged material and a cap of impervious soil was less expensive and required less land than construction with only impervious soil. At the conclusion of the first planning iteration, additional work remained to be done to address headwater flooding along North and South Gabouri Creeks.

It should be noted that the recommended plan in the March 1980 Ste. Genevieve, Missouri Survey Report was similar to a combination of Measures 1, 2, and 3. In the first planning iteration which followed the Board of Engineers for Rivers and Harbors review of the Survey Report, Measures 1, 2, and 3 were found to have severe adverse impacts on the cultural resources in Ste. Genevieve. These measures require the demolition or relocation of some historic buildings, and the high levees and floodwalls flanking both North and South Gabouri Creeks would have extremely high visibility and would adversely effect the historic

character of the community. These effects are described in APPENDIX E - CULTURAL RESOURCES. Discussion with local interests at the end of the first iteration revealed that they have reservations about Measures 1, 2, and 3 because of adverse effects on historic resources, the high visibility of the measures, and the large number of urban properties that would have to be taken to construct the measures. Measures 1, 2, and 3 were eliminated from further consideration at the end of the first planning iteration.

3.1.3 Second Iteration.

All of the measures examined in the first iteration were presented to non-Federal interests. Ste. Genevieve elected officials and officers of Ste. Genevieve County Levee District #3, which is chartered to protect the town of Ste. Genevieve, found Measure 6 to be the most desirable plan. However, the officers of Ste. Genevieve County Levee District #2 asked that Measure 6 be modified so that it would have less impact on the agricultural area protected by the private Levee District #2 levee. Three modifications of Measure 6 were developed in the second iteration, and they were numbered Measures 9, 10 and 11.

The second iteration also included the development of additional structural and nonstructural measures that addressed headwater flooding on North and South Gabouri Creeks. Five measures were developed which

included such features as channel widening, bridge modifications, small levees, clearing and snagging, relocation of structures, elevating structures, and floodproofing.

A modified recreation measure was also developed during the second iteration, including facilities associated with tributary channel widening and with Mississippi River levee measures. All the recreation facilities would be located on flood control lands.

a. Levee Measures.

Measure 9 ties into high ground at the same locations as Measure 6, but the levee alinement avoids the area protected by the existing Levee District #2 agricultural levee, see PLATE A-11. The interior drainage features of Measure 9 were developed through a detailed hydrologic and hydraulic analysis and a period-of-record analysis that showed how the project would have functioned if it had been in place since 1939. The Measure 9 interior drainage system includes a 650 cfs pump station.

Measure 10 was proposed by the officers of Levee District #2. It is similar to Measure 9 but locates the levee on the east and south side of Valle Spring Branch, see PLATE A-12. In Measure 10 the flows from Valle Spring Branch, as well as those from North and South Gabouri Creeks, would be pumped during high stages on the Mississippi River. Measure 10

includes an 800 cfs pump station. Part of the Measure 10 urban design height levee would serve as a northern flank for the Levee District #2 agricultural levee system.

Measure 11 is very similar to Measure 6 except that the downstream end of the levee ties into high ground south of Valle Spring Branch. Valle Spring Branch flows into the area behind the levee. Measure 11 was proposed by some officers of Levee District #2 because less protected agricultural land is required than for Measure 6, and because Measure 11 would provide urban design flood protection for part of the levee district and act as a strong northern flank for the remaining agricultural levee system. The Levee District #2 agricultural levee within Measure 11 would be degraded to provide additional ponding area. Measure 11 includes a 650 cfs pump station and is shown on PLATE A-13.

b. Tributary Clearing and Snagging Measures.

Clearing and snagging involves clearing debris and gravel bars out of the channel bottom, and clearing brush and trees from the channel bottom and sides up to the top of banks.

Measure 18 is clearing and snagging on South Gabouri Creek from just upstream of the Missouri Illinois Railroad crossing near Main Street (mile 1.7) to a point behind the Knights of Columbus hall (mile 2.1). Measure 19 is clearing and snagging on North Gabouri Creek from the

St. Louis and San Francisco Railroad crossing (mile 1.25) to Third Street (mile 1.49). Measures 18 and 19 are shown on PLATE A-14.

c. Tributary Channel Widening and Levee Measures.

Channel widening and small levee measures were developed to reduce damages from headwater flooding due to rainfall within the North and South Gabouri Creek watersheds. These measures complement the major levee measures that would protect the community from Mississippi River flooding. The channel widening measures were designed with a limited channel width so the historic setting along the streams would not be adversely effected. The small levees were also designed to be unobtrusive.

The channel widening design includes gabions on one side of the stream which would stabilize the existing bank slope, and enlargement on the opposite side of the creek, including sloping back the bank to a 2 horizontal to 1 vertical slope. The toe of the grass covered slope would be stabilized with riprap. In stream areas where development constricts the channel enlargement opportunities, gabions would be utilized on both sides of the stream.

Measure 12 addresses flooding on South Gabouri Creek. It includes channel widening from the St. Louis and San Francisco Railroad crossing (mile 1.35) to a point upstream of Tenth Street (mile 2.58), bridge

removal at Third Street and replacement at Seventh, Eighth, Ninth, and Tenth Streets, channel wing walls at the Fourth and Sixth Street bridges, a 3-foot high levee on the left side of the stream from the railroad embankment (mile 1.35) to high ground at the Moses Austin house (mile 1.63), and a short segment of raised street on South Gabouri Street. Measure 13 addresses flooding on North Gabouri Creek. It includes channel widening from the St. Louis and San Francisco Railroad bridge (mile 1.26) to a point upstream from Fourth Street (mile 1.88), bridge replacements at North Main Street and Fourth Street, and a 5-foot high levee on the right bank of the stream from the high ground at the Missouri Farmers Association grain elevator (mile 1.38) to the hill west of the Khoury League baseball fields (mile 1.52). The measures also include clean out of debris from under unimproved bridges. Measures 12 and 13 are shown on PLATE A-15.

d. Tributary Nonstructural Measure.

Measure 22 is a nonstructural measure designed to complement the major levee measures that would protect the community from Mississippi River flooding. Measure 22 provides protection from the 25-year floods on North and South Gabouri Creeks, with some residual damages in the basements of buildings.

Measure 22 addresses the 28 structures flooded above the first floor by the 25-year tributary floods. Residual basement damages occur in 28 homes, five of which are historic.

Measure 22 includes buying 13 properties, taking down the structures, and restoring the lots; buying a small mobile home park and having owners move the mobile homes, two of which are flooded above the first floor by the 25-year flood; building a 5-foot high levee along the right side of North Gabouri Creek from the Khoury League ball fields to the Missouri Farmers Association grain elevator property, protecting 9 structures that are flooded above the first floor by the 25-year flood plus other structures; floodproofing the Bilt Best Window Company warehouse; raising the Robert house 3 feet and raising the ground around the house 2 feet; and ignoring two commercial structures that would not sustain damages even though the 25-year flood is above the first floor. Measure 22 is shown on PLATE A-16.

Measure 22 will be modified at a later date if the University of Missouri historical survey finds any of the 13 structures planned to be taken down to be historical structures. Any historical structure flooded above the firt floor by the 25-year flood would be treated similar to the Robert house.

e. Recreation Measure.

The second iteration recreation measure, Measure 16, addresses recreation opportunities associated with the channel widening and levee measures along North and South Gabouri Creeks and with the major Mississippi River levees. Measure 16 provides the following features: 2

softball fields (1 will replace an existing baseball field at the Khoury League Field), 18 picnic tables, 4.2 miles of hiking and bicycling trails, 2 foot bridges, 1 exercise trail, and parking for 28 cars. All of these facilities would be located on lands purchased for flood damage reduction projects. Measure 16 is shown on PLATE A-17. Additional detail on Measure 16 is presented in APPENDIX G - RECREATION .

f. Evaluation of Second Iteration Measures.

(1) Level of Protection.

The second iteration levee measures that protect against Mississippi River flooding were designed to protect Ste. Genevieve from the Urban Design Flood (UDF) with three feet of freeboard. This UDF is essentially the same as the 500-year flood. Interior drainage systems were designed to utilize the agricultural area for ponding and minimize damages from ponding in the urban areas. The systems would prevent the hypothetical 25-year 9-day duration interior rainfall from ponding to the point where urban damages would begin to occur.

The tributary clearing and snagging measures provide 1-year protection from tributary flooding. Flood profiles are lowered slightly when compared to the existing conditions flood profiles, but the 2-year floods are damaging on North and South Gabouri Creeks.

The sizes of the tributary channel widening and levee measures were guided by the objective of providing the highest reasonable level of protection from tributary flooding without detracting from the historic setting. Measure 12 provides a 25-year level of protection on South Gabouri Creek and Measure 13 provides the same protection on North Gabouri Creek. Both measures have a small amount of residual damages from a 25-year flood, and damages would occur from higher floods.

The scope of the tributary nonstructural measure was decided based on analysis of several levels of protection and the objective of obtaining the highest level of protection possible while not adversely impacting the historic setting. Measure 22 provides protection from the 25-year floods on North and South Gabouri Creek, with some residual damages in the basements of buildings.

TABLE A-7 provides a summary of the levels of protection provided by the second iteration measures.

(2) Costs.

Cost estimates for the second iteration measures were developed in October 1982 dollars, and annual interest and amortization costs were determined using a 7-7/8% interest rate. Information on the cost estimates is presented in APPENDIX D - DESIGN AND COST ESTIMATES. The total costs and annual costs for the second iteration measurers are shown in TABLE A-8.

TABLE A-7
LEVELS OF PROTECTION
PROVIDED BY SECOND ITERATION MEASURES

	From Mississippi River Floods In Average Recurrence Interval (Years)	From North Gabouri Creek Flooding In Average Recurrence Interval (Years)	From South Gabouri Creek Flooding In Average Recurrence Interval (Years)	From Ponding Interior Drainage Assuming Miss. River is High Ave. Rec. Int. (Years)
Measure 9 Levee Mississippi	500 (UDF)	1	1	25
Measure 10 Levee Mississippi	500 (UDF)	1	1	25
Measure 11 Levee Mississippi	500 (UDF)	1	1	25
Measure 12 Chan/Levee S. Gabouri	2	1	25 1/	Not Applicable
Measure 13 Chan/Levee N. Gabouri	2	25 1/	1	Not Applicable
Measure 16 Recreation On Tribs & Levee	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Measure 18 Clear & Snag S. Gabouri	2	1	1	Not Applicable
Measure 19 Clear & Snag N. Gabouri	2	1	1	Not Applicable
Measure 22 Nonstructural N. & S. Gabouri	2	25 1/	25 1/	Not Applicable

1/ Minor residual flood damages occur during 25-year flood.

TABLE A-8
COSTS OF SECOND ITERATION MEASURES
OCTOBER 1982 PRICE LEVEL

	Total First Cost ($1000)	Interest During Construction ($1000)	Total Project Cost ($1000)	Annual Int. & Amt. @ 7-7/8% ($1000)	Annual Operation & Maint. ($1000)	Annual Replacement Cost ($1000)	Total Annual Cost ($1000)
Measure 9 Levee Mississippi	26,800	4,221	31,021	2,444	65	3.9	2,513
Measure 10 Levee Mississippi	28,300	4,457	32,757	2,581	74	4.3	2,659
Measure 11 Levee Mississippi	27,000	4,253	31,253	2,462	74	3.7	2,540
Measure 12 Chan/Levee S. Gabouri	3,000	0	3,000	236	1	0.7	238
Measure 13 Chan/Levee N. Gabouri	1,550	0	1,550	122	1	0.5	124
Measure 16 Recreation On Tribs & Levee	150	0	150	12	7	0.01	19
Measure 18 Clear & Snag S. Gabouri	14	0	14	1	1	0	2
Measure 19 Clear & Snag N. Gabouri	8	0	8	0.6	1	0	1.6
Measure 22 Nonstructural N. & S. Gabouri	1,100	0	1,100	86	2	0.3	88

(3) Economic, Recreation and Ecological Benefits.

A summary of economic, recreation and ecological benefits resulting from the second iteration measures is presented in TABLE A-9. Additional detail on these benefits is presented in APPENDICES F, G, AND H.

(4) Cultural Resources Effects.

Measure 9, 10, 11, 12 and 13 substantially reduce the flood threat to many historic homes. Measures 18, 19 and 22 provide almost negligible reductions in the flood threat. The measures accomplish benefits without adversely affecting the historical setting in Ste. Genevieve.

A summary of the effects of the second iteration measures upon the cultural resource is presented in TABLE A-10. Additional detail in presented is APPENDIX E - CULTURAL RESOURCES.

(5) Ecological Effects.

A summary of the ecological effects of the second iteration measures is presented in TABLE A-11. Additional detail is presented in APPENDIX F - ECOLOGICAL RESOURCES.

TABLE A-9
ECONOMIC RECREATION AND ECOLOGICAL BENEFITS
FROM SECOND ITERATION MEASURES

	Annual Urban Benefits ($1000)	Annual Agricultural Benefits ($1000)	Annual Recreation Benefits ($1000)	Annual Ecological Benefits ($1000)	Total Annual Benefits ($1000)
Measure 9 Levee Mississippi	340.7	3.7	0	9.0	353.4
Measure 10 Levee Mississippi	353.7	3.4	0	10.6	367.7
Measure 11 Levee Mississippi	353.7	2.6	0	12.3	368.6
Measure 12 Chan/Levee S. Gabouri	53.0	0	0	0	53.0
Measure 13 Chan/Levee N. Gabouri	25.3	0	0	0	25.3
Measure 16 Recreation On Tribs. & Levee	0	0	45.2	0	45.2
Measure 18 Clear & Snag S. Gabouri	3.8	0	0	0	3.8
Measure 19 Clear & Snag N. Gabouri	10.0	0	0	0	10.0
Measure 22 Nonstructural N. & S. Gabouri	97.0	0	0	0	97.0

TABLE A-10
SUMMARY OF EFFECTS ON CULTURAL RESOURCES
SECOND ITERATION MEASURES

	Measure 9	Measure 10	Measure 11	Measure 12	Measure 13	Measure 16	Measure 18	Measure 19	Measure 22
Surviving historic buildings	Protects all but one; adversely affects none.	Protects all; adversely affects none.	Protects all; adversely affects none.	Provides 25-year protection for all on S. Gabouri; improves damages for all other events; adversely affects none.	Provides 25-year protection for all on N. Gabouri; improves damages for all other events; adversely affects none.	No effect.	Improves damage estimates for 4 on S. Gabouri; but leaves buildings subject to all events.	Improves damage estimates for 2 on N. Gabouri; but leaves buildings subject to all events.	Provides 25-year protection for all on both tributaries; but changes no damage estimates for less frequent events.
Spatial, chronological, and architectural associations of historic district	No direct effect; indirect beneficial effect highly likely.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	No effect.	No direct effect.	Same as Measure 18.	Same as Measure 18.
Visual and aesthetic character	No adverse effect; indirect beneficial effect highly likely.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	No effect.	Same as Measure 16.	Same as Measure 16.	Same as Measure 16.
Distinctive characteristics of historic buildings	No adverse effect; indirect beneficial effect highly likely.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	No effect.	Same as Measure 16.	Same as Measure 16.	Same as Measure 16.
Community significance	No effect; indirect beneficial effect highly likely.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	No effect.	Same as Measure 16.	Same as Measure 16.	Same as Measure 16.
Archaeological resources	Moderately likely to affect archaeological sites.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	Same as Measure 9.	No effect.	Same as Measure 16.	Same as Measure 16	Same as Measure 16.

TABLE A-11
SUMMARY OF ECOLOGICAL IMPACTS
SECOND ITERATION MEASURES

Ecological Resources	Measure 9	Measure 10	Measure 11	Measure 12	Measure 13	Measure 16	Measure 18	Measure 19	Measure 22
Prime Farmland	Loss of 76.0 acres. 385 ac protected	Loss of 89.3 acres. 421 ac protected	Loss of 89.7 acres. 575 ac protected	NSI	NSI	NSI	NSI	NSI	NSI
Wetlands	Gain of 79.4 acres	Gain of 86.6 acres	Gain of 102.6 acres	NSI	NSI	NSI	NSI	NSI	NSI
Groundwater	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI
Water Quality	NSI	NSI	NSI	Minor, temporary decrease	Minor, temporary decrease	NSI	Minor, temporary decrease	Minor, temporary decrease	NSI
Endangered Species	Minor decrease in potential Indiana bat summer habitat (1340 ft) Minor increase for 2 state-listed plants.	Minor increase in potential Indiana bat summer habitat (1180 ft) Minor increase for 2 state-listed plants.	Minor decrease in potential Indiana bat summer habitat (1570 ft) Minor increase for 2 state-listed plants.	Minor decrease in potential Indiana bat summer habitat (2857 ft)	Minor decrease in potential Indiana bat summer habitat (2059 ft)	NSI	Minor decrease in potential Indiana bat summer habitat (2112 ft)	Minor decrease in potential Indiana bat summer habitat (2270 ft)	NSI
Floodplain Forest	Net loss of 8.2 acres	Net loss of 3.3 acres	Net loss of 4.5 acres			NSI	Minor decrease by removing trees within stream banks	Minor decrease by removing trees within stream banks	NSI
Aquatic Resources	Minor decrease in tributaries lengths	Minor decrease in tributaries lengths	Minor decrease in tributaries lengths	Minor decrease 1.23 miles of stream degraded	Minor decrease 0.60 miles of stream degraded	NSI	0.40 miles of stream degraded	0.43 miles of stream degraded	NSI

TABLE A-11 (Cont'd)
SUMMARY OF ECOLOGICAL IMPACTS
SECOND ITERATION MEASURES (Continued)

Ecological Resources	Measure 9	Measure 10	Measure 11	Measure 12	Measure 13	Measure 16	Measure 18	Measure 19	Measure 22
Terrestrial Resources	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Minor decrease in habitat value	Minor decrease in habitat value	NSI	Minor decrease in habitat diversity	Minor decrease in habitat quality	Minor increase where structures are removed
Aesthetics	Moderate increase by protecting structures from flood damage	Moderate increase by protecting structures from flood damage	Moderate increase by protecting structures from flood damage	Minor increase by removing debris from tributaries & protecting structures from flooding	Minor increase by removing debris from tributaries & protecting structures from flooding	NSI	Minor increase by removing debris from tributaries & protecting structures from flooding	Minor increase by removing debris from tributaries & protecting structures from flooding	Moderate increase by removing flooded structures
Sewage Lagoons	NSI	NSI	Flood protection provided	NSI	NSI	NSI	NSI	NSI	NSI
Water Wells	Flood protection provided	Flood protection provided	Flood protection provided	NSI	NSI	NSI	NSI	NSI	NSI

(6) Summary of Evaluation of Second Iteration Measures.

The second iteration measures were evaluated on the basis of costs; economic, recreation and ecological benefits; level of protection; ecological effects; and cultural resources effects. A summary of the evaluation is given in TABLE A-12.

The public involvement program and the Corps of Engineer study through the second iteration showed that all the second iteration measures had some prospect of being included in the recommended plan. Public involvement resulted in levee Measures 6 and 8 being superseded by Measures 9, 10 and 11.

3.2 FLOOD DAMAGE REDUCTION AND RELATED PLANS

Flood damage reduction measures were developed during the first and second iterations of the planning effort. Flood damage reduction plans were developed by combining several second iteration measures as appropriate.

3.2.1 No Corps Action Plan.

The No Corps Action Plan involves no Corps of Engineers project in Ste. Genevieve. Ste. Genevieve will continue to be flooded even though small levees have been constructed in various locations throughout the community. The town will fight future Mississippi River floods by

TABLE A-12
SUMMARY OF EVALUATION
OF SECOND ITERATION MEASURES

	Total First Cost 1/ ($1000)	Total Annual Benefits ($1000)	Total Annual Costs ($1000)	Benefit/ Cost Ratio	Level of Protection Relative to Ag. Levee	Effect on Ecology (+-scale) 3/	Effect on Cultural Resources (Type) 4/
Measure 9 Levee Mississippi	26,800	353.4	2,513	0.14	+ 2/	0	Type 1
Measure 10 Levee Mississippi	28,300	367.7	2,659	0.14	+	+1	Type 1
Measure 11 Levee Mississippi	27,000	368.6	2,540	0.15	+	+1	Type 1
Measure 12 Chan/Levee S. Gabouri	3,000	53	238	0.22	N.A.	0	Type 1
Measure 13 Chan/Levee N. Gabouri	1,550	25.3	124	0.20	N.A.	0	Type 1
Measure 16 Recreation On Tribs. & Levee	150	45.2	19	2.4	N.A.	0	N.A.
Measure 18 Clear & Snag S. Gabouri	14	3.8	2	1.9	N.A.	0	Type 3
Measure 19 Clear & Snag N. Gabouri	8	10	1.6	6.3	N.A.	0	Type 3
Measure 22 Nonstructural N. & S. Gabouri	1,100	97	88	1.10	N.A	0	Type 1

1/ October 1982 price level.
2/ (+) indicates levee is higher than Federal agricultural levees.
3/ (+- scale) is explained in APPENDIX F - ECOLOGICAL RESOURCES
4/ Type 1=overall beneficial effect, where measure accomplishes significant flood protection in a manner compatible with cultural resources; Type 2=overall adverse effect, where measures accomplish flood protection but directly cause adverse effect to cultural resource; Type 3=measures which directly cause adverse effect to cultural resource and/or leave numerous historic buildings susceptible to frequent floods.

constructing sandbag and other levees, relocating movable items, and other efforts. Some of the levees constructed during future flood emergencies will be left in place, and additional small levees will be constructed in preparation for floods.

Local efforts to control future floods on North and South Gabouri Creeks will probably include occasional channel cleanouts on both streams. Channel widening projects on the tributaries be undertaken using Federal Community Development funds. Levees constructed along North Gabouri Creek for Mississippi River flooding will reduce damages from tributary flooding if closures are made. Over the next 100 years it is probable that several bridges over the tributary streams will be replaced with structures that are less of an impediment to flood flows.

Floodplain zoning will result in some reduction in flood damages over the next 100 years. Some buildings in the floodplain will probably become dilapidated and be taken down. Zoning ordinances will either keep the property from being redeveloped or force construction at a level where the new building is less susceptible to flooding.

Restoration will take place in some historic buildings that have not been flooded in the past but are subject to flooding from the 100 or 500 year floods. Some frequently flooded historic buildings will be abandoned, fall into disrepair, and eventually collapse, and a portion of the Nation's heritage will be forever lost. Other historic buildings

will continue to be used as residences, rental property, or commercial buildings.

3.2.2 Plan 1.

Plan 1 is a combination of Measures 9, 12, 13, and 16. It includes a major urban height levee that protects Ste. Genevieve from Mississippi River flooding, an interior drainage system that includes gravity drains and a 650 cfs pump station, channel widening with gabion slope protection on the tributary streams, bridge replacements and modifications on the tributary streams, small levees along the tributaries, and recreation facilities on land purchased for flood protection projects. This plan provides 500-year protection from Mississippi River flooding, and 25-year protection on North and South Gabouri Creek with minor residual damages. Plan 1 is shown on PLATE A-18.

3.2.3 Plan 2.

Plan 2 is a combination of Measures 10, 12, 13, and 16. It is similar to Plan 1 except that the urban height levee in Plan 2 is located on the south and east side of Valle Spring Branch. Since the Valle Spring Branch watershed drains into the area protected by the levee, an 800 cfs pump station is required to handle interior drainage. Larger gravity drain capacity is also required. Measure 10 was proposed by the officers of Ste. Genevieve County Levee District #2. The plan provides

500-year protection from Mississippi River flooding and 25-year protection on North and South Gabouri Creeks with minor residual damages. It protects a few more structures than Plan 1, including an historic home. Plan 2 is shown on PLATE A-19.

3.2.4 Plan 3.

Plan 3 is a combination of Measures 11, 12, 13, and 16. It is similar to Plans 1 and 2 except that the urban height levee in Plan 3 is east of the Ste. Genevieve sewage lagoon and well east of Valle Spring Branch. The levee is less visible from the south part of Ste. Genevieve than the Mississippi River levees in Plans 1 or 2. The levee also protects more structures than Plan 1, including an historic home, because it ties into high ground south of Valle Spring Branch. Plan 3 includes degrading parts of the existing Levee District #2 agricultural levee to increase the area available for ponding. This increased ponding capacity generally compensates for the additional drainage area in the Valle Spring Branch watershed, and the pump station required for Plan 3 is the same as for Plan 1, 650 cfs. Plan 3 provides the same level of protection as Plans 1 and 2. Plan 3 is shown on PLATE A-20.

3.2.5 Plan 4.

Plan 4 is a combination of Measures 18 and 19, and some features of Measure 22. It includes clearing and snagging on South and North Gabouri

Creeks, a small levee along North Gabouri Creek, and floodproofing the Bilt Best Window Company warehouse. All the features of Plan 4 have net tangible economic benefits in excess of costs as measured in monetary terms. The second iteration recreation measure was not included in Plan 4 because it must be implemented in association with channel widening on the tributary streams and a levee along the Mississippi River. Plan 4 is shown on PLATE A-21.

3.2.6 Evaluation of Plans.

a. Fulfillment of Specific Study Area Objectives.

The degree to which each plan fulfills the specific study area objectives described in the Main Report is presented in TABLE A-13.

b. Level of Protection.

Plans 1, 2 and 3 are combinations of measures, and the levels of protection provided by each plan reflect the levels of protection provided by the measures that make up the plan. Plan 4 does not significantly improve the flood protection in Ste. Genevieve over the without project condition. TABLE A-14 shows the level of protection provided by the plans.

TABLE A-13
FULFILLMENT OF SPECIFIC STUDY AREA OBJECTIVES
FLOOD DAMAGE REDUCTION AND RELATED PLANS

Planning Objectives	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
1. Reduce damages to historic resources, economic losses, other losses caused by Mississippi River flooding.	Flood damages sustained from 5-yr flood	High Level fulfillment (500yr-UDF)	High Level fulfillment (500yr-UDF)	High Level fulfillment (500yr-UDF)	Flood damages sustained from 5-year flood
2. Reduce damages to historic resources, economic losses, Other losses caused by N. & S. Gabouri Creeks	Flood damages sustained from 2-yr flood	Partial fulfillment (Ponding-25yr) (Headwater-25yr)	Partial fulfillment (Ponding-25yr) (Headwater-25yr)	Partial fulfillment (Ponding-25yr) (Headwater-25yr)	Flood damages sustained from 2-year flood
3. Preserve and enhance historic character	Character damaged by floods & flood fight levees	Fulfills through flood protection	Fulfills through flood protection	Fulfills through flood protection	Character damaged by floods & flood fight levees
4. Increase outdoor recreation	No effect	Partial fulfillment	Partial fulfillment	Partial fulfillment	No effect
5. Safeguard and improve ecological and archeological resources	Indirect adverse effect due to flood damages to arch. resources	Minor pos. & neg. effects	Minor pos. & neg. effects	Minor pos. & neg effects	Indirect adverse effect due to flood damages to arch. resources

TABLE A-14
LEVELS OF PROTECTION PROVIDED
BY FLOOD DAMAGE REDUCTION AND RELATED PLANS

	From Mississippi River Floods In Average Recurrence Interval (Years)	From North Gabouri Creek Flooding In Average Recurrence Interval (Years)	From South Gabouri Creek Flooding In Average Recurrence Interval (Years)	From Ponding Interior Drainage Assuming Miss. River is High Ave. Rec. Int. (Years)
No Corps Action Plan	2	1	1	Not Applicable
Plan 1	500 (UDF)	25 1/	25 1/	25
Plan 2	500 (UDF)	25 1/	25 1/	25
Plan 3	500 (UDF)	25 1/	25 1/	25
Plan 4	2	1	1	Not Applicable

1/ Minor residual flood damages occur during 25-year flood.

c. Costs.

Cost estimates for Plans 1, 2, 3 and 4 were developed in October 1982 dollars, and annual interest and amortization costs were determine using a 7-7/8% interest rate. Detailed information on the cost estimates is presented in APPENDIX D - DESIGN AND COST ESTIMATES. The total costs and annual costs for the plans are shown in TABLE A-15.

d. Economic, Recreation and Ecological Benefits.

A summary of economic, recreation and ecological benefits resulting from Plans 1, 2, 3 and 4 is presented in TABLE A-16. Additional detail on these benefits is presented in APPENDICES F, G, and H.

e. Cultural Resources Effects.

Plans 1, 2, and 3 protect historic buildings and archaeological sites from Mississippi River and North and South Gabouri Creek flooding. Either a No Corps Action Plan or Plan 4 would fail to protect cultural resources from flood damage. Therefore, the No Corps Action Plan and Plan 4 both constitute neglect that may result in the deterioration or destruction of the Ste. Genevieve National Register property, and both would, by definition, have an adverse effect on the property (36 CFR 800.9 (e)).

TABLE A-15
COSTS OF FLOOD DAMAGE REDUCTION AND RELATED PLANS
OCTOBER 1982 PRICE LEVEL

	Total Flood Control First Cost ($1000)	Total Recreation First Cost ($1000)	Total First Cost ($1000)	Interest During Construction ($1000)	Total Project Cost ($1000)	Annual Int & Amort @ 7-7/8% ($1000)	Annual Operation & Maint. ($1000)	Annual Replacement Cost ($1000)	Total Annual Cost ($1000)
No Corps Action Plan	0	0	0	0	0	0	0	0	0
Plan 1	31,350	150	31,500	6,005	37,505	2,955	74	5	3,034
Plan 2	32,850	150	33,000	6,323	39,323	3,098	83	6	3,187
Plan 3	31,550	150	31,700	6,092	37,792	2,978	83	5	3,066
Plan 4	410	0	410	0	410	32	3	0.3	35

TABLE A-16

ECONOMIC, RECREATION AND ECOLOGICAL BENEFITS
FROM FLOOD DAMAGE REDUCTION AND RELATED PLANS

	Annual Urban Benefits ($1000)	Annual Agricultural Benefits ($1000)	Annual Recreation Benefits ($1000)	Annual Ecological Benefits ($1000)	Total Annual Benefits ($1000)
No Corps Action Plan	0	0	0	0	0
Plan 1	448.0	4.3	45.2	9.0	506.5
Plan 2	460.2	4.0	45.2	10.6	520.0
Plan 3	460.2	3.0	45.2	12.3	520.7
Plan 4	49.2	0	0	0	49.2

A summary of the cultural resources effects of the plans is presented in TABLE A-17. Additional detail in presented in APPENDIX E - CULTURAL RESOURCES.

f. Ecological Effects.

A summary of the ecological effects of the plans is presented in TABLE A-18. Additional detail is presented in APPENDIX F - ECOLOGICAL RESOURCES.

g. Completeness.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Plans 1, 2 and 3 are complete except that normal operations, maintenance and replacements are needed, and other private and public funds will be required to restore historic buildings in Ste. Genevieve. Plan 4 is not complete because actions and investments would be required to maintain a cleared and snagged condition on the tributary streams, maintain and operate floodproofing features, and maintain and restore the small levee.

TABLE A-17
SUMMARY OF EFFECTS ON CULTURAL RESOURCES
FLOOD DAMAGE REDUCTION AND RELATED PLANS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
Surviving historic historic buildings	Damages sustained from 5-year Mississippi River and 2-year tributary floods.	Protects all but one from UDF. Adversely effects none. High likelihood of indirect beneficial effect.	Same as Plan 1, but provides complete UDF protection.	Same as Plan 2.	Same as No Corps Action Plan.
Spatial, chronological and architectural associations of historic district	Indirect adverse effect through flood-caused attrition.	No adverse effect. Beneficial effect results from flood protection.	Same as Plan 1.	Same as Plan 1.	Same as No Corps Action Plan.
Visual and aesthetic character	No direct effect.	No adverse effect. Flood protection highly likely to provide beneficial effect.	Same as Plan 1.	Same as Plan 1.	Same as No Corps Action Plan.
Distinctive characteristics of historic buildings	Damages sustained from 5-year Miss. and 2-year tributary floods.	Opportunities for restoration, rehabilitation enhanced.	Same as Plan 1.	Same as Plan 1.	Same as No Corps Action Plan.
Community significance	No direct effect.	Opportunities for in-place preservation enhanced.	Same as Plan 1.	Same as Plan 1.	Same as No Corps Action Plan.
Archaeological resources	Indirect adverse effect through flood damage.	Moderately likely to affect archeologicals sites.	Same as Plan 1, though effect more likely.	Same as Plan 2.	Same as No Corps Action Plan.

TABLE A-18
SUMMARY OF ECOLOGICAL IMPACTS
FLOOD DAMAGE REDUCTION AND RELATED PLANS

Ecological Resource	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
Prime Farmland	Continued periodic flooding 595 acres	Loss of 76.0 ac. Protection of 385 ac.	Loss of 89.3 ac. 421 acres protected	Loss of 89.7 ac. 575 ac. protected	NSI
Wetlands	NSI	Increase of 79 acres	Increase of 93 acres	Increase of 108 acres	NSI
Groundwater	NSI	NSI	NSI	NSI	NSI
Water Quality	Continued degradation of South Gabouri Creek from lime mine discharges.	Minor, temporary decrease	Minor, temporary decrease	Minor, temporary decrease	Minor, temporary decrease
Endangered Species	NSI	Loss of 6255 feet of low quality potential Indiana bat summer habitat. Minor increase for 2 state listed plants.	Loss of 3736 feet of low quality potential Indiana bat summer habitat. Minor increase for 2 state listed plants.	Loss of 3346 feet of low quality potential Indiana bat summer habitat. Minor increase for 2 state listed plants.	Degradation of 4382 feet of low quality potential Indiana bat summer habitat.
Floodplain Forest	NSI	Minor decrease	NSI	Minor decrease	NSI
Aquatic Resources	NSI	1.83 miles of tributary streams degraded	1.83 miles of tributary streams degraded	1.83 miles of tributary stream degraded	0.83 miles of tributary streams degraded
Terrestrial Resources	NSI	Moderate beneficial impact for wetland species; minor loss of riparian habitat (6255 feet).	Moderate beneficial impact for wetland species; minor loss of riparian habitat (3736 feet)	Moderate beneficial impact for wetland species; minor loss of riparian habitat (3346 feet)	NSI
Aesthetics	NSI	Improvement because flood fight no longer necessary, buildings not damaged, neighborhood renewal.	Improvement because flood fight no longer necessary, buildings not damaged, neighborhood renewal.	Improvement because flood fight no longer necessary, buildings not damaged, neighborhood renewal.	NSI
Sewage Lagoons	NSI	NSI	NSI	Flood protection provided.	NSI
Water Wells	NSI	Flood protection provided.	Flood protection provided.	Flood protection provided.	NSI

h. Effectiveness.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. The effectiveness of each plan is described in TABLE A-13.

i. Efficiency.

Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. Costs of the plans are described in detail in APPENDIX D - DESIGN AND COST ESTIMATES, and are summarized in TABLE A-15.

Plans 1 and 3 are similar in cost, and are both efficient because they both provide a high level of flood protection for the historic resources in Ste. Genevieve, while not adversely affecting the historic setting. Plan 3 costs slightly more than Plan 1, but it protects one additional important historic structure and is less visible from the south part of Ste. Genevieve. Plan 4 is cost effective but it can not be considered efficient because it does not significantly alleviate the specificed problems or realize the specificed opportunities in the study area.

j. Acceptability

Plan 1 is the most acceptable plan. It is the plan desired by the City of Ste. Genevieve and the Ste. Genevieve County Levee District #3. There is no known opposition to Plan 1.

Plan 2 is less acceptable to the City and Levee District #3 because it has higher initial pump station costs and higher pumping operation and maintenance costs than Plan 1.

Plan 3 is less acceptable to the City and Levee District #3 because of higher operation and maintenance costs than Plan 1.

Plan 4 is not acceptable to the City or Levee District #3 or to historical interests.

k. Assessment and Appraisal of Effects.

Assessment is the process of measuring or estimating the effects of an alternative plan. Assessment determines the difference between without-plan and with-plan conditions. Appraisal is the process of assigning social values to the technical information gathered as part of the assessment process. The assessment and appraisal of the effects of the No Corps Action Plan, Plan 1, Plan 2, Plan 3 and Plan 4 are presented in a System of Accounts in TABLE A-19. A summary of the most important parts of the evaluation of the final plans is presented in TABLE A-20.

TABLE A-19
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
NED ACCOUNT					
a. Beneficial Impacts.					
1. Value of Increased Output of Goods and Services	Insignificant	Not Quantified	Not Quantified	Not Quantified	Insignificant
2. Value of Output Resulting from External Economics	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
3. Value of Output Resulting from Use of Unemployed or Underemployed Resources in Construction of Project	N/A	Not Quantified	Not Quantified	Not Quantified	Insignficant
4. Flood Damages Prevented	N/A	$ 452,300	$ 464,200	$ 463,200	$ 49,200
5. Total NED Average Annual Benefits	N/A	$ 506,500	$ 520,000	$ 520,700	$ 49,200
b. Adverse Impacts.					
1. Project Costs Equivalent Annual	$0	$ 2,955,000	$ 3,098,000	$ 2,978,000	$ 32,000
2. Annual Operation, Maintenance, and Replacement Costs	$0	$ 79,000	$ 89,000	$ 88,000	$ 3,000
3. Total Average Annual Cost	$0	$ 3,034,000	$ 3,187,000	$ 3,066,000	$ 35,000
c. Net NED Benefits	N/A	$-2,527,500	$-2,667,000	$-2,545,300	$ 14,200
d. Benefit-to-Cost Ratio	N/A	0.17	0.16	0.17	1.4

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
ENVIRONMENTAL QUALITY ACCOUNT					
a. Environmental Quality Enhanced - Location of impacts is national in scope occurring locally.					
*1. Man-made Resources	None	Protects French colonial structure and other residences from 500-year flood from Mississippi River and 25-year flood on tributaries. Also protects water wells.	Protects French colonial structures and other residences from 500-year flood from Mississippi River. Provides 25-year level of protection from tributaries with residual basement damages in 28 homes, 5 of which are historic.	Protects French colonial structures and other residences from 500-year flood from Mississippi River and 25-year flood on tributaries. Also protects water wells and sewage lagoons.	Very minor protection.
*2. Natural Resources					
*(a) Air Quality	None	None	None	None	None
*(b) Water Quality	None	None	None	None	None
(c) Wetlands	None	79.4 ac created	86.6 ac created	102.6 ac created	None
(d) Soils (Cropland)	None	Reduced flooding of 385 ac.	Reduced flooding of 421 ac.	Reduced flooding of 575 ac.	None
(e) Prime Farm Land	None	Reduced flooding of 385 ac.	Reduced flooding of 421 ac.	Reduced flooding of 575 ac.	None
(f) Terrestrial Ecosystems	None	Moderate beneficial impact for wetland species.	Moderate beneficial impact for wetland species.	Moderate beneficial impact for wetland species.	None
(g) Aquatic	None	None	None	None	None
(h) Threatened & Endangered Species	None	None	None	None	None

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
ENVIRONMENTAL QUALITY ACCOUNT (Continued)					
*3. Noise	None	None	None	None	None
4. Archaeological Sites	None	Indirect beneficial effect to sites protected.	Indirect beneficial effect to sites protected.	Indirect beneficial effect to sites protected.	None
*5. Historic Resources	None	High-level protection provides beneficial effect.	High-level protection provides beneficial effect.	High-level protection provides beneficial effect.	None
6. Aesthetics	None	Moderate increase by protecting structures from flood damage. Minor increase by removing debris from streams.	Moderate increase by protecting structures from flood damage. Moderate increase by removing flooded structures.	Moderate increase by protecting structures from flood damage. Minor increase by removing debris from streams.	Moderate increase by removing debris from streams.
b. Environmental Quality Degraded or Destroyed - Location of impacts is national in scope but accruing locally.					
*1. Man-made Resources	Continued flooding of French Colonial and other structures as well as water wells and sewage lagoons by Mississippi River and tributaries.	None	13 structures will be destroyed.	None	Continued flooding of French Colonial and other structures as well as water wells and sewage lagoons by Mississippi River and tributaries.
*2. Natural Resources					
*(a) Air Quality	None	None	None	None	
*(b) Water Quality	Continued degradation of South Gabouri Creek from lime minedischarges.		Minor, temporary decrease.	None	Minor, temporary decrease.
(c) Wetlands	None	3.4 ac of forrested slough destroyed.	3.4 ac of forrested slough destroyed.	3.4 ac of forrested slough destroyed.	None
(d) Soils (Cropland)	Continued flooding from Mississippi River of 1,040 ac.	Loss of 241 ac.	Loss of 264 ac.	Loss of 298 ac.	None

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
ENVIRONMENTAL QUALITY ACCOUNT (Continued)					
(e) Prime Farm Land	Continued flooding from Mississippi River.	Loss of 76.0 ac.	Loss of 89.3 ac.	Loss of 89.7 ac.	None
(f) Terrestrial Ecosystem	None	Loss of 6,255 feet of riprarian habitat.	None	Loss of 3,346 feet of riprarian habitat.	None
(g) Aquatic Ecosystem	None	1.83 miles of tributary streams degraded.	Minor decrease in tributary stream length.	1.83 miles of tributary streams degraded.	0.83 miles of tributary streams degraded.
(h) Threatened & Endangered Species	None	Loss of 6,255 feet of low quality potential Indiana bat summer habitat.	None	Loss of 3,346 feet of low quality potential Indiana bat summer habitat.	Degradation of 4,382 feet of low quality potential Indiana Bat summer habitat.
*3. Noise	None	Temporary increase during construction.	Temporary increase during construction.	Temporary increase during construction.	Temporary increase during construction.
4. Archaeological Sites	Indirect adverse effect thr~ugh neglect.	None	None	None	Indirect adverse effect through neglect.
*5. Historic Sites	Indirect adverse effect through neglect.	None	None	None	Indirect adverse effect through neglect.
6. Aesthetics	Continued degradation of structures due to continued flooding.	None	None	None	None

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
SOCIAL WELL-BEING ACCOUNT					
a. Beneficial Impacts.					
1. Educational, Cultural, & Recreational Opportunities	None	Protection of National Historic Area & recreational provisions of 18 picnic tables, 4 bike parking racks, parking spaces for 28 vehicles, 2 softball diamonds, 1 exercise trail, and 4.2 miles of hiking and with biking trail one new bridge. (All recreational provisions are on flood control lands.)	Protection of National Historic Area & recreational provisions of 18 picnic tables, 4 bike parking racks, parking spaces for 28 vehicles, 2 softball diamonds, 1 exercise trail, and 4.2 miles of hiking and with biking trail one new bridge. (All recreational provisions are on flood control lands.)	Protection of National Historic Area & recreational provisions of 18 picnic tables, 4 bike parking racks, parking spaces for 28 vehicles, 2 softball diamonds, 1 exercise trail, and 4.2 miles of hiking and with biking trail one new bridge. (All recreational provisions are on flood control lands.)	Insignificant
*2. Community Cohesion	Insignificant, resulting from floodfight efforts.	Decreases the interruptions in all forms of community activities, i.e., commercial, social, etc., while improving the possibility of individuals who would leave area to remain thus stabilizing family unit. Encourages up keep of structures no longer subject to as frequent flooding.	Decreases the interruptions in all forms of community activities, i.e., commercial, social, etc., while improving the possibility of individuals who would leave area to remain thus stabilizing family unit. Encourages up keep of structures no longer subject to as frequent flooding.	Decreases the interruptions in all forms of community activities, i.e., commercial, social, etc., while improving the possibility of individuals who would leave area to remain thus stabilizing family unit. Encourages up keep of structures no longer subject to as frequent flooding.	Insignificant
*3. Occupation & Industry	None	Decreases damages to commercial, industrial & historic structures & lessens frequency & duration of interruptions of economic activities, protects 385 acres of agricultural land.	Decreases damages to commercial, industrial & historic structures & lessens frequency & duration of interruptions of economic activities, protects 377 acres of agricultural land.	Decreases damages to commercial, industrial & historic structures & lessens frequency & duration of interruptions of economic activities, protects 538 acres of agricultural land.	Insignificant

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
SOCIAL WELL-BEING ACCOUNT (Continued)					
*4. Displacements					
(a) Residential (b) Farms	Not Quantified, resulting from flood destruction.	None	None	None	Insignificant
5. Community Growth	None	Improves opportunities for more individuals to remain in or migrate to area.	Improves opportunities for more individuals to remain in or migrate to area.	Improves opportunities for more individuals to remain in or migrate to area.	Insignificant
*6. Property Values	None	Increases due to decrease in frequency and extent of flooding and related damages.	Increases due to decrease in frequency and extent of flooding and related damages.	Increases due to decrease in frequency and extent of flooding and related damages.	Insignificant
*7. Availability of Public Facilities & Services	None	Improves due to decrease in frequency & extent of flooding which precludes usage of facilities and halts services.	Improves due to decrease in frequency & extent of flooding which precludes usage of facilities and halts services.	Improves due to decrease in frequency & extent of flooding which precludes usage of facilities and halts services.	Insignificant
8. Safety/Public Health	None	Improves due to decrease in frequency & severity of flooding.	Improves due to decrease in frequency & severity of flooding.	Improves due to decrease in frequency & severity of flooding.	Insignificant
*9. Aesthetic Values	Insignificant, resulting from absence of man-made flood control measures.	Increase due to community structures, facilities, & amenities not subject to as frequent nor as severe flooding while encouraging better maintenance of area.	Increase due to community structures, facilities, & amenities not subject to as frequent nor as severe flooding while encouraging better maintenance of area.	Increase due to community structures, facilities, & amenities not subject to as frequent nor as severe flooding while encouraging better maintenance of area.	Insignificant

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
SOCIAL WELL-BEING ACCOUNT (Continued)					
b. Adverse Impacts.					
*1. Community Cohesion	Continued interruptions in community activities, i.e., commercial, social, etc., while not helping individuals to remain in family unit area.	None	None	None	None
*2. Occupation & Industry	Continued damage to commercial, industrial, & historic structures as well as interruptions of economic activities and flooding of agricultural acreage, all of which may hurt employment opportunities.	Uses 253 agricultural acres for construction.	Uses 278 agricultural acres for construction.	Uses 310 agricultural acres for construction.	None
*3. Displacements					
(a) Residential (b) Farms	Continued damage & degradation from flooding could cause relocation of affected individuals.	None	None	None	None
4. Community Growth	Continued frequent & severe flooding could retard or possibly prevent projected growth.	None	None	None	None
5. Educational, Cultural, & Recreational Opportunities	Continued degradation of National Historic Area by flooding.	None	None	None	None
*6. Property Values	Decreases due to continued damage, degradation, and destruction by flooding.	None	None	None	None

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
*7. Availability of Public Facilities & Services	Continued interruption of use of facilities and receipt of services.	None	None	None	None
8. Safety/Public Health	Does not improve due to severity & frequency of flooding.		None	None	None
*9. Aesthetic Values	Continued decrease due to community structures, facilities, & amenities being subject to frequent and severe flooding which can cause degradation due to lack of maintenance.	Insignificant decrease due to visibility of man-made measures.	Insignificant decrease due to visibility of man-made measures.	Insignificant decrease due to visibility of man-made measures.	Insignificant decrease due to visibility of man-made measures.
REGIONAL DEVELOPMENT ACCOUNT					
a. Beneficial Impacts.					
1. Population	None	Improves opportunities for individuals to remain in or migrate to area.	Improves opportunities for individuals to remain in or migrate to area.	Improves opportunities for individuals to remain in or migrate to area.	Insignificant
*2. Employment	None	Decreases damages to commercial, industrial, & historic structures & lessens frequency & duration of interruptions of economic activities, protects 385 acres of agricultural land.	Decreases damages to commercial, industrial, & historic structures & lessens frequency & duration of interruptions of economic activities, protects 377 acres of agricultural land.	Decreases damages to commercial, industrial, & historic structures & lessens frequency & duration of interruptions of economic activities, protects 538 acres of agricultural land.	Insignificant
3. Income-Multiplier Effects of Project Induced NED Income Changes	NA	Not Quantified, Insignificant	Not Quantified, Insignificant	Not Quantified, Insignificant	Insignificant

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-19 (Continued)
SYSTEM OF ACCOUNTS

	No Corps Action Plan	Plan 1	Plan 2	Plan 3	Plan 4
*4. Desirable Growth & Stability	None	Improves likelihood of occurrence of projected minor growth & continued stability.	Improves likelihood of occurrence of projected minor growth & continued tability.	Improves likelihood of occurrence of projected minor growth & continued stability.	Insignificant
*5. Government Revenues, State & Local	None	Improves due to reduction in interruptions of economic activities and decrease in flood related Government costs.	Improves due to reduction in interruptions of economic activities and decrease in flood related Government costs.	Improves due to reduction in interruptions of economic activities and decrease in flood related Government costs.	Insignificant
b. Adverse Impacts.					
1. Population	Could retard or possibly prevent projected growth.	None	None	None	None
*2. Employment	May hurt employment opportunities due to flood damages to commercial, industrial & historic structures & agricultural acreage & interruptions of economic activities.	None	None	None	None
3. Income-Multiplier Effects of Project Induced NED Income Changes	NA	None	None	None	None
*4. Desirable Growth & Stability	Could threaten likelihood of projected minor growth & continued stability.	None	None	None	None
*5. Government Revenues, State & Local	Continued loss of revenues due to interruption of economic activities and flood related Government costs.	None	None	None	None

* Items specifically required by Public Law 91-611, Section 122.

TABLE A-20
SUMMARY OF EVALUATION
FLOOD DAMAGE REDUCTION AND RELATED PLANS

	Total Annual Benefits ($1000)	Total Annual Costs ($1000)	Benefit/ Cost Ratio	Level of Protection	Effect on Ecology	Effect on Cultural Resources
No Corps Action Plan	0	0	N.A.	No protection provided. Urban damages from 5-year Mississippi River flood, 2-year North & South Gabouri Creeks.	None	Continued damages to unique historical resources, and impediment to restoration. Adverse effect due to neglect.
Plan 1	506.5	3034	0.17	500-year Mississippi River, 25-year ponding, 25-year North Gabouri, 25-year South Gabouri.	No significant impacts.	Major flood protection for unique historical resources, removal of impediment to restoration.
Plan 2	520.0	3187	0.16	500-year Mississippi River, 25-year ponding, 25-year North Gabouri, 25-year South Gabouri.	No significant impacts.	Major flood protection for unique historical resources, removal of impediment to restoration. Plus protects one additional historic building.
Plan 3	520.7	3066	0.17	500-year Mississippi River, 25-year ponding, 25-year North Gabouri, 225-year South Gabouri.	Minor net beneficial effect.	Major flood protection for unique historical resources, removal of impediment to restoration. Plus protects one additional historic building.
Plan 4	49.2	35	1.4	Same as No Corps Action Plan	Minor net adverse effect.	Same as No Corps Action Plan

3.2.7 National Economic Development Plan.

The National Economic Development Plan (NED Plan) is the plan that reasonably maximizes net national economic development benefits, consistent with the Federal objective. The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements.

The Ste. Genevieve, Missouri study examined many types and increments of flood damage reduction measures designed to protect the community from Mississippi River flooding, tributary flooding, or both. Of all the flood damage reduction measures examined, the only measures that had net NED benefits were clearing and snagging on South and North Gabouri Creeks (Measures 18 and 19), the small levee along North Gabouri Creek (part of Measure 22), and the floodproofing of the Bilt Best Window Company warehouse (part of Measure 22). Plan 4 is a combination of these measures and features and is the Nation Economic Development Plan (NED Plan).

3.2.8 Environmental Quality Plan.

The environmental quality plan (EQ plan) is the same as Plan 3. It was formulated under the following criteria, listed in priority:

a. Maximize benefits to cultural (historic) resources.

b. Include opportunities for other environmental resources as feasible.

c. Include opportunities for recreation as feasible.

Additional discussion on the environmental features in the measures in the EQ plan is presented below.

a. Measure 11 - This levee protects all the historic structures and is less visible form the south part of Ste. Genevieve than Measures 9 and 10. It also protects the sewage lagoon. Borrow areas used to construct the levee will be converted to marshes. Levees will be mowed after 1 August to avoid destruction of ground nesting wildlife.

b. Measure 12 and 13 - These measures consist of widening portions of North and South Gabouri Creeks to reduce flooding to historic structures from these creeks. The channels would be widened from one side only to preserve the riparian vegetation on the opposite bank. Riparian forest would be cleared between 15 October and 1 April to avoid potential impacts to Indiana bat nursery colonies (also applies to Measure 11).

c. Measure 16 - Hiking and bicycling trails would be constructed along North and South Gabouri Creeks and on the levee.

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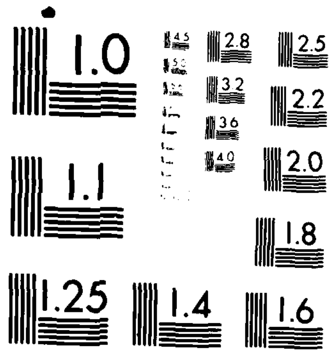

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NATIONAL BUREAU OF STANDARDS 1963-A

d. General conditions for all measures - Land purchased for project purposes will be developed for recreation and/or environmental purposes as appropriate.

3.2.9 Selection of the Final Plan and Justification of Departure from the NED Plan.

The District Engineer of the St. Louis District, Corps of Engineers selected Plan 1 as the best plan to reduce flood damages and provide related benefits in Ste. Genevieve, Missouri. The City of Ste. Genevieve and Ste. Genevieve County Levee District #3 have stated their intent to act as the non-Federal co-sponsor for Plan 1.

Under the Water Resource Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, the NED Plan is to be selected unless there is an overriding reason for selecting another plan, based on other Federal, state, local, and international concerns.

The NED plan was not selected because it is so small in scale that it does not meet the planning objectives. The economic and environmental benefits provided by the plan are insignificant when compared to the flooding problems in Ste. Genevieve and the debilitating effects of continued flooding on the unique historical resources in the community.

Flood damages are still experienced along both North and South Gabouri Creeks with the NED plan in place, in fact damages are still sustained along both streams from the 2-year flood. The historic buildings along North and South Gabouri Creeks are still highly susceptible to tributary headwater flooding with the NED plan in place. As an example, the French colonial Robert house, built in 1797, is still damaged by the 2-year North Gabouri Creek flood. Higher floods on the tributaries will damage many structures and historical buildings with the NED plan in place.

The NED plan provides only incidental protection from the most important flood problem in Ste. Genevieve, the disastrous Mississippi River floods. The extent, depths and durations of the Mississippi River floods far exceed those on the tributary streams. As has been discussed at length in this report, Mississippi River floods cause major economic damages, tremendous social disruption, and irreparable damage to the unique internationally significant historical buildings in Ste. Genevieve. Mississippi River flooding is the primary reason why the community is seeking Federal help in solving their flood problem, and the NED plan is unable to properly address this key objective.

The exception to the requirement to select the NED plan is further justified by the fact that flooding of the historical buildings in Ste. Genevieve is a matter of local, state, National, and international concern. The National Trust for Historic Preservation and the United

States Department of the Interior are very concerned about the flood problem and have supported Federal flood protection for the community. Both the French and Canadian consulates have expressed concern about the effects of flooding on the French and French Canadian heritage in Ste. Genevieve.

Plan 1 was selected rather than Plan 2 because Plan 2 is more costly due to the larger pump station required to handle the additional flows from the Valle Spring Branch watershed. Plan 2 also has higher annual pump operation, maintenance, and replacement costs.

Although Plan 3 is an attractive plan from the environmental quality standpoint, Plan 1 was selected rather than Plan 3 because Plan 3 has higher operation and maintenance costs and because Plan 3 was not supported by Levee District #2.

STE. GENEVIEVE, MISSOURI

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APPENDIX B

PUBLIC VIEWS AND RESPONSES

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APPENDIX B

PUBLIC VIEWS AND RESPONSES

See the PUBLIC VIEWS AND RESPONSES section in VOLUME ONE of this report.

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FEASIBILITY REPORT

APPENDIX C

HYDROLOGY AND HYDRAULICS

STE. GENEVIEVE, MISSOURI

APPENDIX C

HYDROLOGY AND HYDRAULICS

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APPENDIX C

HYDROLOGY AND HYDRAULICS

PLATES

PLATES (Cont'd)

SECTION 1 - PURPOSE AND SCOPE

The purpose of this appendix is to present the hydrologic and hydraulic analyses for the Ste. Genevieve flood control study. Historical floods of record are described, flooding problems are identified, and potential flood reducing measures are presented. Extensive computer modeling techniques were developed to simulate existing conditions and examine impacts of future flood control improvements.

SECTION 2 - DESCRIPTION OF STUDY AREA

The study area covered by this appendix includes the watersheds of North Gabouri Creek and South Gabouri Creek and the Mississippi River between river miles 122.0 and 125.0. (*Plate C-1*). Valle Spring Branch was not included as part of the detailed hydrologic/hydraulic analyses because of the minor flood problems it contributes to the City of Ste. Genevieve. Ste. Genevieve, Missouri is located along the right bank of the Mississippi River floodplain, approximately 50 miles south of St. Louis and 60 miles north of Cape Girardeau, Missouri. A large portion of the city is subject to flooding from the Mississippi River as well as flash flooding from North and South Gabouri Creeks.

North Gabouri Creek originates about 6 miles west/southwest of the city of Ste. Genevieve, Missouri and flows to the east/northeast through the city before combining with South Gabouri Creek to form Gabouri Creek and enters the Mississippi River at mile 122.5. The North Gabouri Creek drainage basin includes an area about 7.43 square miles from the upper drainage divide near Zell, Missouri, to the St. Louis-San Francisco and Missouri-Pacific Railroad twin bridges. The basin is long and narrow with an average channel slope about 51.4 feet per mile before entering the Mississippi River floodplain. The upper portion of the basin is relatively steep with slopes exceeding 200 feet per mile. Majority of the area in the upper reaches is cropland/pasture or deciduous forest land with little urban development. Residential and commercial development are apparent in the lower reaches, mostly within the city limits. The floodplain of North Gabouri Creek varies in width from approximately 200-300 feet in the upper reaches to about 600-700 feet in the lower reaches.

South Gabouri Creek also originates about 6 miles southwest of the city of Ste. Genevieve and travels parallel with North Gabouri Creek to its confluence with Gabouri Creek. Like North Gabouri Creek, the drainage basin of South Gabouri Creek is narrow and long and comprises of 6.23 square miles as it extends from the drainage divide near Interstate 55 to the Missouri-Pacific Railroad bridge upstream of Main Street.

South Gabouri Creek has an average slope of 43.9 feet per mile as it meanders along the course of the Missouri-Pacific Railroad throughout its length. Although most of the basin is cropland/pasture and forest land, industrial and commercial growth has been expanded outside the city limits with residential development remaining primarily within the city limits. The floodplain of South Gabouri Creek varies in width from about 200-300 feet in the upper reaches to 600-700 feet in the lower reaches.

Valle Spring Branch is located mostly due south of the City of Ste. Genevieve and flows east to the Mississippi River floodplain. It lies adjacent to South Gabouri Creek and has a drainage area of 3.41 square miles.

Topography near the study area varies from gently rolling hills in the uplands to flat floodplain near the Mississippi River. Karst topography with sink holes, mines and gravel pits are very common in each basin.

The total width of the Mississippi River floodplain at Ste. Genevieve from bluff to bluff is approximately 21,000 feet. The width from the Prairie du Rocher Levee District levee on the left bank of the Mississippi River to the city of Ste. Genevieve is about 8,000 feet.

SECTION 3 - AVAILABLE DATA

3.1 STREAM GAGE RECORDS

Available stream gage records on the Mississippi River include limited data at Chester, Illinois (RM 109.9), approximately 13 miles downstream of Ste. Genevieve, and Little Rock Landing (RM 125.5), approximately 2.5 miles upstream of Ste. Genevieve, Missouri. The Chester gage provides such information as daily stages dating back to the early 1900's and a rating-curve updated in 1978. The Little Rock Landing gage provides only daily stage readings at river mile 125.5. No stream gage records exist along North and South Gabouri Creeks or Valle Spring Branch.

3.2 RAINFALL RECORDS

Hourly rainfall records are available at Sparta, Illinois, about 20 miles northeast of Ste. Genevieve. Although an hourly recording station at Prairie du Rocher was closer to the study site, Sparta's rainfall records were used in this study because of its availability and lengthy period of record. There are no recording stations from the National Weather Service within the study basin, but many local residents have kept well documented records of rainfall events as well as high water marks. Recent severe floods have produced many well documented high

water marks in the basin and were helpful in model calibrations of North and South Gabouri Creeks, as will be explained later. Some historical high water marks along North and South Gabouri Creeks were obtained from local newspaper articles of past floods, personal interviews with local citizens, and field observations in the general vicinity of Ste. Genevieve, Missouri.

SECTION 4 - HISTORICAL EVENTS

The city of Ste. Genevieve is prone to flooding from the Mississippi River, North and South Gabouri Creeks, or any combination thereof. Although the major source of flooding is due largely from the Mississippi River, North and South Gabouri Creeks have produced numerous flash floods causing moderate damage. Headwater or backwater flooding can occur at any time of the year although most frequently in the spring and early summer months.

4.1 MISSISSIPPI RIVER

The most damaging flood from the Mississippi River occurred on 30 April 1973 with a peak gage height of 43.3 feet (384.4 NGVD) at Chester, Illinois. This flood was above a flood stage of 27 feet (368.1 NGVD) for 97 consecutive days from 9 March 1973 through 13 June 1973. It was the highest the river had been since 30 June 1844 when a high water mark of 39.83 was recorded at the Chester gage. TABLE C-1 lists major Mississippi River flood events for the period of record at the Chester gage.

TABLE C-1
MAJOR FLOODS OF RECORD
MISSISSIPPI RIVER
AT CHESTER, ILLINOIS[1]

Year	Date	Duration[2]	Maximum Gage Height	Zero[3]	Discharge (cfs)
1844	30 Jun	--	39.83		1,350,000
1903	13 Jun	16	33.4	127.29	--
1908	21 Jun	35	30.75	127.29	895,000
1909	17, 18 Jul	12	31.0	127.29	890,000
1927	26 Apr	58	34.41	348.13	1,060,000
1929	29 Apr	75	33.1	348.13	878,000
1935	8 Jun	38	32.8	340.83	697,000
1942	1 Jul	22	34.0	341.05	-
1943	24 May	49	38.08	341.05	873,000
1944	2 May	46	37.55	341.05	842,000
1947	4 Jul	65	38.17	341.05	886,000
1951	23 Jul	61	39.3	341.05	795,000
1969	15 Jul	48	35.73	341.05	644,000
1973	30 Apr	102	43.32	341.05	886,000
1979	16 Apr	61	39.79	341.05	760,000
1982	9 Dec	60	39.8	341.05	831,000
1983	5 May	63	41.02	341.05	740,000

1. Period of record: 1844 through 1983. Stage readings and continuous discharge records since 1891 and 1927, respectively. Stage readings prior to 1965 at river mile 109.5; 1965 to date at river mile 109.9.
2. Duration = consecutive days above flood stage. Flood stage = 26.0 feet, prior to 1945. Flood stage = 27.0 feet, 1945 to date.
3. Zero of gage. 1891 to 1912 Engineer Office Datum (0 = 127.29), 1911 to 1931 Memphis datum (0 = 348.13), 1932 to 1936 Mean Gulf Level (0 = 340.83), and 1936 to date Mean Sea Level or National Geodetic Vertical Datum (0 = 341.05).

4.2 NORTH AND SOUTH GABOURI CREEKS

The most severe flash flood from local intense rainfall within North and South Gabouri basins occurred on Easter Sunday evening, 21 April 1957. The Ste. Genevieve Herald's April 26, 1957 edition documents that "Although Ste. Genevieve itself experienced almost three inches of rain in a half-hour period, the downpour at Zell and vicinity measured unofficially at five inches or more." This flood had been the most damaging since 1922 and the highest of memory among some of the older citizens. The impact and approximate height of the flood waters at 603 LaHaye was shown through photographs in the "Ste. Genevieve Herald" (27 April 1957) and the "Fair Play" (26 April 1957).

Some of the more recent flash floods along North and South Gabouri Creeks occurred on 31 March 1977, 11 April 1979, and 3 and 24 December 1982. The Ste. Genevieve Herald (31 March 1977) reported that "Mr. Jim Woelich ...... recorded four inches of rain in Ste. Genevieve Sunday and Monday....... The rainfall on and off covered a period of around 30 hours over the weekend, ending shortly after 8 a.m. Monday......" The worst spot was said to be at the railroad tressle over Main Street where South Gabouri Creek water swelled to about 4 1/2 feet on Main Street.

In 1979, the Ste. Genevieve Herald reported "During the first 6 hours of rain, upwards of 3 inches were reported at locations in the area...... Hard hit was the Washington and Third Street near the North Gabouri Creek channel. Nearly every low-lying stretch along the Gabouri Creeks was affected by the flash flooding."

The flash floods of 3 and 24 December 1982 created numerous flood problems along both Gabouri Creeks. One local resident reported 5.4 inches and 5.7 inches of rain at Zell, Mo. on 3 and 24 December, respectively. The City of Ste. Genevieve was reported to get about 5.0 inches and 5.5 inches of rain on 3 and 24 December, respectively. Surveyed high water marks from the 24 December flash flood indicated that North and South Gabouri Creeks experienced between a 2-year and 5-year recurrence interval flood events at the upper reaches in town and near a 25-year at the lower reaches (where backwater from the Mississippi River was also a flooding source).

SECTION 5 - EXISTING PROTECTION

The City of Ste. Genevieve has little or no protection from the Mississippi River, North or South Gabouri Creeks other than an emergency flood control plan which involves sandbagging operations. Two levee districts near Ste. Genevieve area include: Ste. Genevieve County Levee District No. 2 and Ste. Genevieve County Levee District No. 3.

5.1 STE. GENEVIEVE LEVEE DISTRICT NO. 2.

The Ste. Genevieve County Levee District No. 2 maintains an earthen levee along the right bank of Valle Spring Branch from U.S. Highway 61 to the St. Louis-San Francisco Railroad (PLATE 2 MAIN REPORT). It continues from the eastern bank of the sewage lagoon and follows the right bank of the Mississippi River to the Kaskaskia Island levee. This levee district protects only agricultural land in the Mississippi River flood plain and has approximately a 10-year level of protection from the Mississippi River. It apparently provides some protection from both Gabouri Creeks and Valle Spring Branch.

5.2 STE. GENEVIEVE COUNTY LEVEE DISTRICT NO. 3.

The Ste. Genevieve County Levee District No. 3 was organized to provide the City of Ste. Genevieve with emergency flood protection within the city limits (PLATE 1 MAIN REPORT). Presently no reliable earthen levees have been constructed by this levee district although recent flooding has developed the need for emergency levees in problem areas.

5.3 LOCAL FLOOD CONTROL EMERGENCY PLAN.

The City of Ste. Genevieve obtains most of its present flood protection through extensive sandbagging operations managed by the City and Ste. Genevieve County Levee District #3 with assistance from the

Corps of Engineers. If time warrants and forecasts are available, sand (and/or limestone chat) is delivered to specific sites within the city for filling of the bags. The local flood control emergency plan is only temporary and provides some means of protection if ample time is available to sufficiently distribute and construct a sandbag levee. The sandbagging procedure is used mostly for protection from the Mississippi River, although once in place, it provides some benefit to local residents from North and/or South Gabouri Creek flash floods.

SECTION 6 - HYDROLOGIC AND HY RAULIC ANALYSES

Computer models were used to perform the hydrologic and hydraulic analyses described in this report. Two computer programs in particular were extensively used for developing the computer models. The computer program "HEC-1 Flood Hydrograph Package" was used to model the rainfall-runoff process of various hypothetical events for North and South Gabouri Creeks. The computer program "HEC-2 Water Surface Profiles" was use to determine the water surface profiles for the Mississippi River and North and South Gabouri Creeks.

6.1 HYDROLOGIC MODEL

6.1.1 Mississippi River

No HEC-1 model was developed for the Mississippi River. Discharge values in the HEC-2 model were taken from the "Upper Mississippi River

Water Surface Profiles, River Mile 0.0 to River Mile 847.5," completed for the Upper Mississippi River Basin Commission in November 1979. The following summarizes discharge-frequency relationships between Chester (RM 109.9) and Brickey's Landing (RM 136.0).

Reach	RECURRENCE INTERVAL 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	UDF
	(Flows x 1000)						
Chester to Kaskaskia River (RM 109.9 - RM 117.5)	476	650	760	905	1010	1120	1420
Kaskaskia River to Brickey's Landing (RM 117.5 - RM 136.0)	460	630	735	875	980	1085	1380

6.1.2 North and South Gabouri Creeks

North and South Gabouri Creek basins were divided into 9 and 6 subareas, respectively, as shown in PLATE C-1. Each tributary was initially sub-divided to reflect potential dry detention sites of which five sites on North Gabouri and two sites on South Gabouri were selected for preliminary modeling. However, due to the minor flood reduction and high construction costs of each or combinations thereof, the only site seriously considered was along the lower basin of North Gabouri Creek, as will be discussed later. Twenty-four hour SCS synthetic unit hydrographs with ten minute intervals were developed for each of the tributaries using HEC-1. Soil maps provided by the Soil Conservation Service

indicate that the dominate soil types in each basin are the Goss-Menfro complex and Menfro silt loam in the uplands and Haymond silt loam in the flood plains, all being in the hydrologic soil group B. Small portions of land between subareas in the uplands were of the Weingarten series with a hydrologic soil group C. A weighted SCS curve number was computed for each subarea based on existing land use maps prepared by the Southeast Missouri Regional Planning and Economic Development Commission (SMRPEDC), and the SCS Handbook of Hydrology. TABLE C-2 lists the present land use/cover and weighted area number for each subarea of North and South Gabouri Creeks. Future land use for the City of Ste. Genevieve within the next ±20 years will be mostly northwestward with little or no increase in urbanization in the uplands. Thus, the only increase in runoff due to increased urbanization will occur in the lower subareas of each tributary basin. TABLE C-3 lists the future land use/cover and weighted curve number for each subarea based on projected future conditions by the year 2000.

The time of concentration was computed for each subarea by the Kirpich formula, travel time = $(11.9L^3/H)^{.385}$ and multiplied by 0.6 to estimate the time of concentration (SCS lag). Basin characteristics such as drainage area, length, height or vertical drop, travel time, SCS lag and slope for North and South Gabouri Creeks are shown on TABLE C-4 for existing conditions.

TABLE C-2

LAND USE FOR

NORTH AND SOUTH GABOURI CREEKS

EXISTING CONDITIONS

North Gabouri Creek

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
10	Cropland and Pasture	1.19	70	77	90%	10%	70.7	70%	
	Deciduous Forest Land	.51	60	73	90%	10%	61.3	30%	
		1.70 sq. mi.							68
20	Cropland and Pasture	.30	70	77	83%	17%	71.2	40%	
	Deciduous Forest Land	.44	60	73	83%	17%	62.2	60%	
		.74 sq. mi.							66
30	Cropland and Pasture	.38	70	77	65%	35%	72.5	48%	
	Deciduous Forest Land	.41	60	73	65%	35%	64.6	52%	
		.79 sq. mi.							68
40	Cropland and Pasture	.28	70	77	83%	17%	71.2	60%	
	Deciduous Forest Land	.19	60	73	83%	17%	62.2	40%	
		.47 sq. mi.							68

TABLE C-2 (Continued)

North Gabouri Creek (Continued)

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
50	Cropland and Pasture	.58	70	77	85%	15%	71.1	85%	
	Deciduous Forest Land	.10	60	73	85%	15%	62.0	15%	
		.68 sq. mi.							70
60	Cropland and Pasture	.33	70	77	100%	-	70	63%	
	Deciduous Forest Land	.20	60	73	100%	-	60	37%	
		.53 sq. mi.							66
70	Cropland and Pasture	.33	70	77	90%	10%	70.7	30%	
	Deciduous Forest Land	.77	60	73	90%	10%	61.3	70%	
		1.10 sq. mi.							64
80	Residential	.02	75	83	100%	-	75	2%	
	Cropland and Pasture	.92	70	77	100%	-	70	90%	
	Deciduous Forest Land	.08	60	73	100%	-	60	8%	
		1.02 sq. mi.							69
90	Residential	.36	75	83	100%	-	75	90%	
	Commercial	.02	92	94	100%	-	92	5%	
	Cropland and Pasture	.02	70	77	100%	-	70	5%	
		.40 sq. mi.							76

TABLE C-2 (Continued)

South Gabouri Creek

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
100	Cropland and Pasture	1.29	70	77	90%	10%	70.7	80%	
	Deciduous Forest Land	.32	60	73	90%	10%	61.3	20%	
		1.61 sq. mi.							69
110	Cropland and Pasture	.09	70	77	90%	10%	70.7	10%	
	Deciduous Forest Land	.84	60	73	90%	10%	61.3	90%	
		.93 sq. mi.							63
120	Industrial	.23	88	91	83%	17%	88.5	7.5%	
	Cropland and Pasture	1.87	70	77	83%	17%	71.2	62.5%	
	Deciduous Forest Land	.53	60	73	83%	17%	62.2	17.5%	
	Reservoirs	.08	100	100	83%	17%	100.0	2.5%	
	Mines, Quarries, Gravel Pits	.30	50	50	83%	17%	50.0	10.0%	
		3.01 sq. mi.							70
130	Residential	.10	75	83	100%	-	75	40%	
	Commercial	.02	92	94	100%	-	92	10%	
	Industrial	.04	88	91	100%	-	88	20%	
	Mixed Urban	.02	77	92	100%	-	77	10%	
	Transitional Area	.04	65	65	100%	-	65	20%	
		.22 sq. mi.							78

TABLE C-2 (Continued)

South Gabouri Creek (Continued)

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
140	Residential	.10	75	83	100%	-	75	30%	
	Cropland and Pasture	.22	70	77	100%	-	70	70%	
		.32 sq. mi.							72
150	Residential	.10	75	83	100%	-	75	70%	
	Commercial	.03	92	94	100%	-	92	20%	
	Other Urban	.01	77	82	100%	-	77	10%	
		.14 sq. mi.							79

TABLE C-3

LAND USE FOR

NORTH AND SOUTH GABOURI CREEKS

FUTURE CONDITIONS

North Gabouri Creek

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
10	* * * *	Same as Existing Conditions			* * * *				68
20	* * * *	Same as Existing Conditions			* * * *				66
30	* * * *	Same as Existing Conditions			* * * *				68
40	* * * *	Same as Existing Conditions			* * * *				68
50	* * * *	Same as Existing Conditions			* * * *				70
60	* * * *	Same as Existing Conditions			* * * *				66
70	* * * *	Same as Existing Conditions			* * * *				64
80	Residential	.44	75	83	100%	-	75	43%	
	Commercial	.05	92	94	100%	-	92	5%	
	Mixed or Other Urban	.02	77	82	100%	-	77	2%	
	Cropland and Pasture	.45	70	77	100%	-	70	44%	
	Deciduous Forest Land	.06	60	73	100%	-	60	6%	
		1.02 sq. mi.							73

TABLE C-3 (Continued)

North Gabouri Creek (Continued)

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
90	Residential	.36	75	83	100%	-	75	90%	
	Commercial	.02	92	94	100%	-	92	5%	
	Mixed or Other Urban	.02	77	82	100%	-	77	5%	
		0.40 sq. mi.							76

TABLE C-3 (Continued)

South Gabouri Creek

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
100	* * * *	Same as Existing Conditions			* * * *				69
110	* * * *	Same as Existing Conditions			* * * *				63
120	Residential	.21	75	83	83%	17%	76.4	7%	
	Commercial	.03	92	94	83%	17%	92.3	1%	
	Industrial	.60	88	91	83%	17%	88.5	20%	
	Mixed or Other Urban	.03	77	82	83%	17%	77.8	1%	
	Cropland and Pasture	.99	70	77	83%	17%	71.2	33%	
	Deciduous Forest Land	.45	60	73	83%	17%	62.2	15%	
	Reservoirs	.15	100	100	83%	17%	100.0	5%	
	Mines, Quarries, Gravel Pits	.55	50	50	83%	17%	50.0	18%	
		3.01 sq. mi.							71
130	Residential	.09	75	83	100%	-	75	40%	
	Commercial	.03	92	94	100%	-	92	15%	
	Industrial	.07	88	91	100%	-	88	30%	
	Mixed or Other Urban	.03	77	82	100%	-	77	15%	
		.22 sq. mi.							82
140	Residential	.21	75	83	100%	-	75	67%	
	Commercial	.02	92	94	100%	-	92	5%	
	Cropland and Pasture	.09	70	77	100%	-	70	28%	
		.32 sq. mi.							74

TABLE C-3 (Continued)

South Gabouri Creek (Continued)

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
150	Residential	.10	75	83	100%	-	75	70%	
	Commercial	.03	92	94	100%	-	92	20%	
	Mixed or Other Urban	.01	77	82	100%	-	77	10%	
		.14 sq. mi.							79

TABLE C-4

BASIN CHARACTERISTICS

NORTH AND SOUTH GABOURI CREEKS

EXISTING CONDITIONS

Subarea No.	D.A. (sq. mi.)	Length (mi.)	Height (ft.)	tt[1] (hrs.)	SCS Lag[2] (hrs.)	Slope[3] (ft./mi.)
10	1.70	2.29	350	0.71	0.43	111.2
20	0.74	2.01	317	0.63	0.38	135.7
30	0.79	2.48	432	0.72	0.43	145.7
40	0.47	0.41	397	0.69	0.41	147.9
50	0.68	1.53	312	0.46	0.28	160.4
60	0.53	0.23	193	0.39	0.23	148.7
70	1.10	1.94	201	0.72	0.43	81.6
80	1.02	1.59	198	0.58	0.35	119.4
90	0.40	1.52	156	0.60	0.36	70.8
100	1.61	2.66	185	1.08	0.65	62.4
110	.93	2.015	282	0.66	0.40	124.0
120	3.01	3.294	346	1.08	0.65	69.0
130	.22	0.95	122	0.38	0.23	156.7
140	.32	1.17	134	0.47	0.28	127.2
150	.14	0.79	90	0.35	0.21	94.6

1. Travel Time (hours) = $(11.9\ L^3/H)^{.385}$, where L = total length in miles and H = height in feet.
2. SCS lag = 0.60 x tt
3. Slope = the channel slope determined between between the 15 percent and 85 percent distance of total channel length.

The Muskingum Method was selected for stream routing along the upper reaches of each tributary since water profiles were not needed in such reaches. Values for the Muskingum K coefficient were determined by approximating the channel velocity and computing the travel time with the equation, $K = \frac{L}{V(1.5)3600}$ where L is the routing length in feet and V is the channel velocity in fps. The Muskingum coefficients used for each subarea in the HEC-1 model are listed on TABLE C-5.

The Modified Puls routing method was used in areas where an HEC-2 model was available for each tributary. Storage outflow for this method was obtained directly from the HEC-2 model by computing several water surface profiles based on flow values obtained from the initial HEC-1 model with the Muskingum Method of routing. An HEC-1 schematic of the model for each tributary is shown on PLATE C-2.

TABLE C-5

MUSKINGUM COEFFICIENTS

NORTH AND SOUTH GABOURI CREEKS

Subarea No.	Routing Length (ft.)	Muskingum Coefficients X	Muskingum Coefficients K
20	5500	0.25	0.13
40	2940	0.25	0.07
70	5860	0.25	0.16
80*	6030	0.25	0.19
90*	5570	0.25	0.15
120	15070	0.25	0.56
130*	3500	0.25	0.13
150*	2900	0.25	0.13

*Muskingum Method was computed on first HEC-1 model to estimate flows for initial HEC-2 model. Modified Puls routing method was used on subsequent HEC-1 models based on storage-outflow data from HEC-2.

Point rainfall amounts were obtained for the 50, 20, 10, 4, 2, 1 and 0.2 percent chance of exceedance frequency from Technical Papers 40 and 49 and the National Weather Service Hydro-35. TABLE C-6 lists the rainfall probability-depth-duration relationship for the area near Ste. Genevieve, Missouri. Point rainfall values were later adjusted to annual series and adjusted for drainage area for the various hypothetical storms. Discharges generated from the HEC-1 model for existing conditions at several locations were compared to discharge values computed with empirical equations from: 1) "Techniques for Estimating the Magnitude and Frequency of Missouri Floods," by the U.S.G.S., 1974 and 2) "Regional Frequency Analysis for Streams in the St. Louis District," by the SLD in 1981. The USGS equations are applicable on most Missouri streams for drainage areas ranging from 0.1 to 14,000 sq. mi. and slopes range from 1.0 to 300 ft/mile. The empirical equations developed by the St. Louis District are considered applicable for rural streams within the St. Louis District. Both regression analysis do not apply to large rivers such as the Mississippi River. The results of the discharge comparisons are shown on TABLE C-7.

Water surface profiles were computed with the HEC-2 model for flows developed from the existing HEC-1 model. These profiles differ only slightly from the profiles for future conditions with no project, as will be described later, and are not shown in this report.

TABLE C-6

RAINFALL PROBABILITY-DEPTH-DURATION

NEAR STE. GENEVIEVE, MISSOURI

Duration		Exceedance Probability						
Hrs	Min	50.0%	20.0%	10.0%	4.0%	2.0%	1.0%	.2%
0.08	5	0.45 in.	0.53 in.	0.59 in.	0.68 in.	0.75 in.	0.82 in.	1.18 in.
0.17	10	0.73	0.87	0.98	1.13	1.25	1.37	1.96
0.25	15	0.92	1.11	1.24	1.44	1.60	1.75	2.50
0.50	30	1.26	1.56	1.77	2.07	2.31	2.54	3.24
1.00	60	1.62	2.03	2.32	2.73	3.05	3.37	4.00
2.00	120	1.94	2.43	2.80	3.20	3.55	3.95	4.98
3.00	180	2.17	2.72	3.13	3.50	3.90	4.32	5.40
6.00	360	2.63	3.24	3.68	4.28	4.68	5.18	6.50
12.00	720	3.12	3.82	4.39	4.96	5.55	6.10	7.85
24.00	1440	3.60	4.45	5.05	5.78	6.46	7.10	9.10
48.00	2880	4.15	5.20	5.90	6.90	7.80	8.50	10.20
96.00	5760	4.90	6.25	7.20	8.60	9.50	10.30	12.45
168.00	10080	5.80	7.20	8.30	9.90	10.85	12.20	15.00
216.00	12960	6.10	7.63	9.00	10.57	11.85	13.30	16.60
240.00	14400	6.25	7.85	9.35	10.90	12.35	13.85	17.40

TABLE C-7

DISCHARGE COMPARISON

NORTH AND SOUTH GABOURI CREEKS

EXISTING CONDITIONS

Tributary	Location	Discharge (cfs)											
		50%			10%			2%			1%		
North Gabouri Creek		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	RM. 1.26	1120	1120	1113	2770	2790	3219	4310	5360	5181	4980	6720	6015
				(1141)			(3266)			(5234)			(6072)
	RM. 2.3	1120	1110	1155	2800	2770	3447	4390	5330	5698	5070	6690	6745
				(1176)			(3476)			(5741)			(6790)
South Gabouri Creek													
	RM. 1.68	920	960	667	2210	2370	1958	3390	4560	3196	3900	5730	3785
				(886)			(2333)			(3646)			(4258)
	RM. 2.89	870	910	671	2100	2250	1988	3230	4330	3251	3720	5440	3850
				(897)			(2373)			(3750)			(4360)

(1) "Techniques for Estimating the Magnitude and Frequency of Missouri Floods." U.S.G.S., Open-File Report 1974.

(2) "Regional Frequency Analysis for Streams in the St. Louis District," D.F. 1981.

(3) HEC-1 model results with future condition in parenthesis.

6.2 HYDRAULIC MODEL

6.2.1 Mississippi River

The computer program "HEC-2, Water Surface Profiles" was used to compute the water surface profiles for the Mississippi River between river mile 109.9 at Chester, Illinois, and mile 136.0 at Brickey's Landing. Although the City of Ste. Genevieve is only located between river miles 121.8 and 124.4, the HEC-2 model was extended from the Chester gage to Brickey's Landing gage in order to calibrate the model against known historical floods and calculate any induced flooding for proposed plans. Cross sectional data for the channel and overbank areas were obtained from previous analyses. Manning's roughness coefficients were estimated during flood calibrations and from aerial photography. The 'n' values were 0.030 for channel roughness and varied from 0.04 to 0.08 for overbank areas. Contraction and expansion coefficients for gradual transitions were 0.1 and 0.3, respectively and for abrupt transitions (such as the Chester bridge) 0.3 and 0.5, respectively. A typical cross-section of the Mississippi River at river mile 122.66 is shown on PLATE C-3.

6.2.2 North and South Gabouri Creeks

North and South Gabouri Creeks were also modeled with the HEC-2 computer program. Water surface profiles for North Gabouri Creek originate approximately 4800 feet from the mouth of Gabouri Creek and

extend to mile 3.423. South Gabouri Creek water surface profiles extend from about 6300 feet from the mouth of Gabouri Creek to mile 2.91. Cross sectional data for the channel and overbank areas were obtained from field surveys and topographic aerial photos with a contour interval of two feet. Bridges and other crossings were modeled from actual field surveys taken in 1976-1977. Manning's roughness coefficients were estimated from field observations and aerial photography. The 'n' values estimated for each tributary was 0.05 for the channel and 0.065 for the overbanks. Houses and other buildings were manually added to each cross section of North and South Gabouri Creek as shown on PLATES C-4 and C-5. Contraction and expansion coefficients for gradual transitions were selected as 0.1 and 0.3, respectively. If abrupt transitions occurred at bridges, 0.3 and 0.5 were used for contraction and expansion coefficients, respectively. Within the city limits, North Gabouri Creek is crossed by two railroads and three road bridges while South Gabouri is crossed by three railroads crossings, six road bridges and one footbridge.

6.3 CALIBRATION OF MODELS

6.3.1 Mississippi River

The HEC-2 model for the Mississippi River was calibrated against the crest of the 1973 and 1979 floods and 1979 flood when at flood stage. Discharges in the HEC-2 model were taken from actual recorded flows from the U.S.G.S. Water Resource Data booklets. Starting water surface

elevations were obtained from the stages recorded at the Chester gage (RM 109.9) on the date of each historical flood with no levees assumed crevassed. Discharges were modified to reflect additional inflow from the Kaskaskia River.

The three computed water surface profiles from the HEC-2 model were compared to actual peak stages recorded at Little Rock Landing (RM. 125.5) and Brickey's Landing (RM. 136.0). The model for the 1973 and 1979 floods showed excellent results (within 0.5 foot) of that recorded at the Little Rock and Brickey's Landing gages and also in the vicinity of Ste. Genevieve where 4 high water marks had been documented. TABLE C-8 compares the HEC-2 results with the surveyed high water marks and gages at Little Rock Landing (RM 125.5) and Brickey's Landing (RM 136.0).

6.3.2 North and South Gabouri Creeks

The HEC-2 models for North and South Gabouri Creeks were calibrated against high water marks from the storms of 28 April 1957, 28-29 March 1977 and 11 April 1979.

Rainfall data and high water marks for all three storms were received from local newspaper articles, local citizens and field observations of each tributary. No recording rainfall stations were available for either

TABLE C-8

FLOOD CALIBRATION COMPARISON FOR

MISSISSIPPI RIVER, NORTH GABOURI CREEK AND

SOUTH GABOURI CREEK

EXISTING CONDITIONS

	Date	River Mile	High Water Mark(ft.NGVD)	HEC-2 Model	Diff.	HWM Source
Mississippi River	30 April 1973	122.66	389.8	390.42	+.62	St. Louis District Survey: 9 Aug 82
		123.28	390.54	390.56	+.02	St. Louis District Survey: 9 Aug 82
		125.50	391.29	391.81	+.52	Little Rock Landing gage
		136.00	398.23	398.16	-.07	Brickey's Landing gage
	16 April 1979	122.66	387.2	387.16	-.04	St. Louis District Survey: 9 Aug 82
		123.90	387.8	387.71	-.09	St. Louis District Survey: 9 Aug 82
		125.50	388.59	388.65	+.06	Little Rock Landing gage
		136.00	395.18	395.03	-.15	Brickey's Landing gage
North Gabouri Creek	28 April 1957	1.97	393.0	393.20	+.20	1974 F.P.I. Report
		2.941	410.5	413.06	+2.56	1974 F.P.I. Report
	11 April 1979	1.714	390.0 Est	390.02	+.02	Local Citizen
South Gabouri Creek	28 April 1957	1.985	394.5	393.87	-.63	1974 F.P.I. Report
	31 March 1977	1.689	387.5 Est	387.08	-.42	Local newspaper, the "St. Genevieve Herald"
	11 April 1979	2.071	394.0 Est	394.36	+.36	Local Citizen

basin and any differences in the analysis may be due to insufficient rainfall data. Unit hydrographs and runoff hydrographs for each of the storms were computed with the HEC-1 program. Individual hydrographs for the 9 sub-basins of North Gabouri Creek were combined and routed throughout the system. The upper 3 basins of South Gabouri Creek were combined as one to simplify the model and determine the flow at the city limits (U.S. Highway 61). Curve numbers for each storm were increased to reflect Type III antecedent moisture conditions.

Starting water surface elevations for each storm were determined by interpolating an elevation between Little Rock Landing and Chester gages on the same date as the flash flood. Manning's roughness coefficient for each tributary and each storm event was 0.05 and 0.065 for the channel and overbank, respectively. TABLE C-8 shows the results from the 1957, 1977 and 1979 storms along North and South Gabouri Creeks.

SECTION 7 - WATER SURFACE PROFILES

The computation of water surface profiles discussed below were developed with the HEC-2 computer models after calibration of each model was made to past historical flood events.

7.1 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

7.1.1 Mississippi River

Water surface profiles for existing and future without project conditions for the Mississippi River were considered the same since there is little future levee/reservoir construction within the Mississippi River basin that would affect flood levels at Ste. Genevieve. Frequency profiles for the 5-, 10-, 25-, 50-, and 100-yr recurrence interval floods and the Urban Design Flood (UDF) were developed with starting water surface elevations at the Chester gage taken from the Upper Mississippi River Basin Commission Report (1977) using the results of the Mississippi Basin Model (MBM). The starting water surface elevation for the 2-year recurrence interval event was taken from previous HEC-2 analyses. Hypothetical flood profiles through the 1.0 percent flood event, assumed no levees crevassed. A separate computer run for the UDF was developed assuming the Kaskaskia Island failed and the Prairie du Rocher levee district not failed. TABLE C-9 shows the results from the HEC-2 model as compared to results from the UMRBC profiles. Water surface profiles for future without project condition for the 2-, 5-, 10-, 25-, 50-, 100-year recurrence intervals and UDF between miles 109.9 to 130.0 on the Mississippi River are shown on PLATE C-6. Flooded area maps of the Ste. Genevieve area for the 1973 flood (approx. 30-year), 100-year recurrence interval and UDF are shown on PLATES C-7 through C-10. The stage-frequency relationship at Chester, Little Rock Landing and

TABLE C-9

MISSISSIPPI RIVER

COMPARISON BETWEEN 'MBM' AND HEC-2 MODEL

EXISTING CONDITIONS

	Recurrence Interval						
	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	UDF
Chester Gage (RM 109.9)							
MBM:	370.2	376.1	379.4	383.5	386.7	389.3	390.7
HEC-2 Model:	370.2	376.1	379.4	383.5	386.7	389.3	390.7
Diff.:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Rock Landing (RM 125.5)							
MBM:	380.13	385.6	388.5	391.1	393.6	396.2	400.0
HEC-2 Model:	379.55	384.6	387.41	390.97	393.63	396.02	399.46
Diff.:	-.58	-1.0	-1.09	-.13	+.03	-.18	-.54
Brickey's Landing (RM 136.0)							
MBM:	386.18	391.4	394.8	398.0	400.7	403.4	406.1
HEC-2 Model:	385.84	391.26	394.19	397.82	400.46	402.88	407.59
Diff.:	-.34	-.14	-.61	-.18	-.24	-.52	-1.49

(1) 2-yr elevations taken from contracted work by local firm.
(2) 5-yr, 10-yr, 25-yr, 50-yr, 100-yr and UDF elevation taken from 1977 UMRBC profiles.
(3) HEC-2 model for 2-yr, 5-yr, 10-yr, 25-yr, 50-yr and 100-yr recurrence intervals assumed no levees crevassed. The Urban Design Flood (UDF) assumed: 1) Prairie du Rocker levee not failed, and 2) Kaskaskia Island levee failed but with high 'n' value (.3) in right overbank through Kaskaskia Island Levee District.

Brickey's Landing gages are shown on PLATES C-11, C-12, and C-13, respectively, and display the results from the HEC-2 model as well as actual data points plotted by the Weibull plotting method.

Existing Federal agricultural levees in the study reach have been designed to prevent damage from the 2 percent chance flood and, with rigorous flood fighting procedures, could possibly withstand the 1 percent chance flood. However, flood profiles exceeding the 1 percent chance flood are uncertain since stages for flows greater than the 100-year recurrence interval event will cause failure of various levee units. The Urban Design Flood (1,420,000 cfs at Chester, Illinois) has previously been adopted by the SLD for urban levee and floodwall design at St. Louis (1,300,000 cfs) and Cape Girardeau (1,460,000 cfs) and is equally applicable for Ste. Genevieve, Missouri. Although the UDF is conservatively referred to as a 500-year event in the economic analysis, it is actual rarer since the discharge of the 500-year event is estimated as 1,250,000 cfs at Chester, Illinois. Similarly, past studies of many severe historical storms performed by the SLD, WES and others have found that the most severe combination of actual flood events (Hypothetical Flood M52A) produced a peak discharge of approximately 1,300,000 cfs at Chester, Illinois. Although the M52A flood was not labeled as the Standard Project Flood (SPF), the arrangement of these actual events are similar to the criteria of the SPF. Thus, the UDF protection recommended for the Ste. Genevieve is judged to be similar to an SPF level of protection with either flood event exceeding the 500-year recurrence interval flood discharge.

7.1.2 North and South Gabouri Creeks

Future land use maps prepared by the SMRPEDC to the year 2000 were used to modify the existing HEC-1 models for future conditions without a flood control project. According to the Comprehensive Plan, predicted growth for new development of the city of Ste. Genevieve will be northwestward and south of the present city. However, since Ste. Genevieve is already located mainly within the lower portion of each tributary basin, any increased runoff due to future expansion of the city was found to be insignificant and had a negligible effect on the existing condition profiles. The weighted SCS curve numbers and discharges for future conditions are shown on TABLES C-3 and C-7, respectively. Future without project condition water surface profiles for the 2-, 5-, 10-, 25-, 50-, 100-, 500-yr and Standard Project Flood (SPF) for North and South Gabouri Creeks are shown on PLATES C-14 and C-15, respectively. Flooded area maps for North and South Gabouri Creeks through the Ste. Genevieve area for the 25-year, 100-year and SPF events are shown on PLATES C-16 and C-17. Starting elevations for each frequency were assumed to be at normal depth at the first cross-section. The SPF profile was determined after flows were computed for the Standard Project Storm (SPS) based on criteria and guidelines from Training Document No. 15, "Hydrologic Analysis of Ungaged Watershed Using HEC-1", April 1982, HEC at Davis, Ca. The SPS rainfall was distributed into hourly intervals for a four-day duration storm.

SECTION 8 - FIRST ITERATION

8.1 LEVEE PROFILE DESIGN

Levee design for the first iteration included eight separate measures, all of which provide flood protection to the City of Ste. Genevieve. Measures 1, 2, 3 and 4 flanked the two Gabouri Creeks through town while Measures 5, 6, 7 and 8 were designed away from town in the Mississippi River floodplain (PLATES A-1 through A-8). Where applicable, each measure consisted of three separate levee profiles: 1) The 1973 flood on the Mississippi River coincident with a 50-year tributary flow, 2) the 100-yr recurrence interval flood on the Mississippi River coincident with a 100-year tributary flow; and 3) the Urban Design Flood on the Mississippi River coincident with the Standard Project Flood (SPF) on each tributary. The net levee grade for each measure did not include freeboard or additional levee height for consolidation or settlement.

8.1.1 Measures 1, 2, 3 and 4

A conservative approach for levee design along each tributary for Measures 1 through 4 assumed both left and right banks were built in place and not failed. The levee profiles for each measure were designed to protect the corresponding area of Ste. Genevieve mostly from the

Mississippi River. However, additional levee height was required in the upstream reaches of the flank levee along each tributary to protect against flooding from North and South Gabouri Creeks.

8.1.2 Measures 5, 6, 7 and 8

Levee design profiles for Measures 5, 6, 7 and 8 were based solely on the water surface profiles form the Mississippi River. No additional levee raise was necessary due to North or South Gabouri Creeks.

8.2 INTERIOR DRAINAGE STUDY

A preliminary interior drainage study for Measures 1 through 8 was developed to screen and analyze each measure in the first iteration. The interior drainage study for each measure consisted of a separate HEC-1 model for each interior subarea. Each model used a ten year storm event to size interior components for damage prevention during blocked or unblocked gravity drain conditions. Blocked gravity drain conditions preclude gravity flow and interior ponded waters could only be removed from the interior system by pumping. Unblocked gravity drain conditions assumed low Mississippi River elevations and interior waters could be drained without pumping. The HEC-1 models did not have the capabilities to remove ponded water within the interior system through a combination of both gravity drain flow and operation of the pumping station.

8.2.1 Measures 1, 2, 3 and 4

1. Pumping Station Design - Minimum capacity of pumping stations for Measures 1, 2, 3 and 4 were based on providing a 10-year level of protection. A family of curves were developed at each pumping station (PLATE C-17A) based on results from a multi-plan, multi-ratio HEC-1 model using the 10-year storm with 48-hour duration at 15 minute intervals as the base flood. Precipitation data for the 25-, 50-, 100- and 500-year recurrence interval floods were multiplied by a ratio equal to the percent increase above the base flood. Multi-plans consisted of various capacities of the pumping station ranging from no capacity to 50 cfs. Peak flows in the HEC-1 models were computed before entering potential storage areas and routed through the available storage adjacent to the pumping stations. Each model included capabilities to remove water via a pump routine dependent on start/stop elevations at the pumping stations. Minimum damage elevations for each measure were taken from the economic structure inventory on the basis of providing maximum storage area with little or no structural damage. An SCS curve number of 88 was used in each model to reflect a highly residential/commercial area. The results for Measures 1, 2, 3 and 4 are summarized on TABLE C-10.

2. Gravity Drain Design - Gravity drains for Measures 1, 2, 3 and 4 were sized for a 10-year 24-hour duration rainfall with 5 minute intervals.

TABLE C-10

PUMPING STATION SUMMARY - FIRST ITERATION

MEASURES 1, 2, 3 AND 4

	10-yr Storm		Drainage	Pumping Station Data				
Measure	Duration	Interval	Area (sq.mi.)	Start/Stop	Minimum Damage Elevation			Capacity (cfs)
				Elev. (NGVD)	Structure No.	Elev. (NGVD)	Storage (acre-ft.)	
1	48 hr.	15 min.	.13	381.5/380.0	#48	383.72	10.5	65 cfs
2	48 hr.	15 min.	.08	382.0/380.0	#827	383.39	8.5	40 cfs
	48 hr.	15 min.	.05	381.5/381.0	#761	384.50	4.1	25 cfs
3	48 hr.	15 min.	.15	382.0/381.0	#326	384.13*	13.3	75 cfs
4	48 hr.	15 min.	.08	382.0/380.0	#827	383.39	8.5	40 cfs
	48 hr.	15 min.	.02	384.0/383.0	#770	384.78	0.7	70 cfs**

*Pre-December 1982 structure inventory elevation. Structure #326 has been resurveyed @ elev. 383.40' NGVD.

**A 70cfs capacity pumping station was necessary to adequately pump the peak discharge since little or no storage is available before the start of damage.

The HEC-1 model computed preliminary peak flows at each gravity drain assuming no storage routing through available ponding areas near each gravity drain. Similar to the pumping station study, an SCS curve number of 88 was used to reflect highly urban conditions. TABLE C-11 summarizes the sizes of gravity drains for Measures 1, 2, 3 and 4.

8.2.2 Measures 5, 6, 7, and 8

1. Pumping Station Design - Sizing of pumping stations for Measures 5, 6, 7, and 8 was somewhat more complex than Measures 1 thru 4 not only because of the additional drainage and storage area but also due to poor drainage of the interior system. TABLE C-12 lists the basin characteristics for the additional local drainage areas of Measures 5, 6, 7, and 8. An HEC-1 schematic for Measures 5 and 6 and Measures 7 and 8 are shown on PLATES C-18 and C-19, respectively. PLATE C-20 shows the interior elevation-storage relationship for each measure. The design storm for pumping stations of Measures 5, 6, 7, and 8 was (initially) a 10-year 24-hour duration rainfall with 10 minute intervals. A short duration storm was initially used to roughly estimate overall costs of the project. Like Measures 1, 2, 3, and 4, pumping capacity-elevation curves were developed for each measure. Assumptions for each measure included: 1) all pumps turned on before interior ponding elevation exceeded out-of-bank conditions (378' NGVD) and turned off when the interior dropped below 376' NGVD, (in-bank conditions), 2) maximum ponding elevation of the interior was initially assumed at 382' NGVD since some damages began at this elevation, and 3) minimum pumping

TABLE C-11

GRAVITY DRAIN SUMMARY - FIRST ITERATION

MEASURES 1, 2, 3 AND 4

Measure	10-yr Storm Duration	10-yr Storm Interval	Drainage Area (sq.mi.)	Peak Discharge (cfs)[1]	Gravity Drain Size[2]
1	24 hr.	5 min.	.13	248	54" Dia.
			.07	193	42" Dia.
			.02	67	30" Dia.
			.01	36	21" Dia.
			.23 sq. mi.		
2	24 hr.	5 min.	.02	64	36" Dia.
			.08	200	48" Dia.
			.003	9	18" Dia.
			.05	114	48" Dia.
			.01	31	30" Dia.
			.02	42	30" Dia.
			.183 sq. mi.		
3	24 hr.	5 min.	.04	120	36" Dia.
			.06	151	36" Dia.
			.05	124	36" Dia.
			.15 sq. mi.		
4	24 hr.	5 min.	.02	64	36" Dia.
			.08	200	48" Dia.
			.003	9	18" Dia.
			.02	65	36" Dia.
			.02	42	30" Dia.
			.143 sq. mi.		

1. Peak discharge results taken from HEC-1 model.

2. Diameter of gravity drains determined from Fig. 4-44, "Handbook of Steel Drainage and Highway Construction Products," 1971. Gravity drains assumed fully paved; therefore, roughness coefficient = .012.

TABLE C-12

BASIN CHARACTERISTICS

FOR LOCAL DRAINAGE AREAS

OF MEASURES 5, 6, 7, AND 8

Measure	Subarea No.	Drainage Area (sq.mi.)	Length (mi.)	Height (ft.)	tt [1] (hrs.)	SCS Lag [2] (hrs.)	Slope [3] (ft./mi.)	Curve No.
5	500	1.097	2.386	167.2	0.99	0.59	0.0133	70
6	600	2.019	2.765	173.2	1.155	0.69	0.0119	70
7	700	0.404	1.061	107.8	0.46	0.28	0.019	70
8	800	1.326	2.083	88.5	1.08	0.65	0.008	70

1. Travel Time (hours) = $(11.9\ L^3/H)^{.385}$, where L = total length in miles and H = height in feet.

2. SCS lag = 0.60 x tt

3. Slope = the channel slope determined between between the 15 percent and 85 percent distance of total channel length.

station capacity was 100 cfs even if no pumps are required - that is, if adequate storage was available in the ponding area, a minimum 100 cfs capacity pumping station was selected during plan formulation as necessary to provide some means of removing the interior water from the system. Seepage from the Mississippi River was not considered in the HEC-1 model although seepage curves were used in the period of record analysis of the St. Louis Interior Drainage Program for the selected plan (Section 11). The initial pumping station results for Measures 5, 6, 7, and 8 are 100 cfs, 100 cfs, 300 cfs, and 400 cfs, respectively, as shown on TABLE C-13. Another computer run compared and verified these results using a 10-year 48-hour duration storm with ten minute intervals and a selected minimum damage elevation of a specific structure protected within the ponding area of each measure rather than 382' NGVD. Results from these computer runs indicated that the initial pumping capacities of each measure were adequate.

2. Gravity Drain Design - Preliminary conditions for gravity drains for Measures 5, 6, 7, and 8 assumed minimum facility to provide essentially the same interior flood relief as the present system. Channel capacities were computed from the continuity equation (Q = AV) and are approximately 50-60 percent of the 10-year discharges computed by HEC-1 before going into storage. Equivalent discharges for the proposed gravity drains were computed from Manning's equation. TABLE C-14 lists the gravity drain sizes selected for Measures 5, 6, 7, and 8.

TABLE C-13

PUMPING STATION SUMMARY - FIRST ITERATION

MEASURES 5, 6, 7, AND 8

	10-Yr. Storm		Total	Pumping Station Data		
			D.A.	Start/Stop		Capacity [1]
Measure	Duration	Interval	(sq. mi.)	Elev. (NGVD)	Maximum Ponding Elevation [1]	(cfs)
5	24 hr.	10 min.	8.527	378.0/376.0	382.0	100 cfs
6	24 hr.	10 min.	15.679	378.0/376.0	382.0	100 cfs
7	24 hr.	10 min.	7.834	378.0/376.0	382.0	300 cfs
8	24 hr.	10 min.	14.986	378.0/376.0	382.0	400 cfs

1. Assumptions: Minimum damage elevation = 382.0 ft. NGVD; Minimum pumping station capacity = 100 cfs.

TABLE C-14
GRAVITY DRAIN SUMMARY - FIRST ITERATION
MEASURES 5, 6, 7, AND 8

Measure	Channel Area Near Drain Site (sq. ft.)	Wetted Perimeter (ft.)	Hydraulic Radius (ft.)	Slope (ft./ft.)	Existing Channel Capacity[1] (cfs)	Equivalent[2] Size Gravity Drain	Equivalent Discharge From Manning's Equation (cfs)
5	466.4	86	5.4	.0019	2100	4 - 102" DIA. CMP 30" DIA. CMP	2080
6	530.4	97.8	5.4	.0022	2600	2 - 10'x 12' Box Culvert 42" DIA. CMP	2600
7	466.4	86	5.4	.0019	2100	4 - 102" DIA. CMP 30" DIA. CMP	2080
8	530.4	97.8	5.4	.0022	2600	2 - 10'x 12' Box Culvert 42" DIA. CMP	2600

[1] Q = AV where velocity was estimated from Manning's nomograph with roughness coefficient = .045

[2] Equivalent size gravity drain design based on discharges from Manning's equation where n = .012 (fully paved). Local interior gravity drains were designed from the Rational Method.

SECTION 9 - SECOND ITERATION

9.1 LEVEE PROFILE DESIGN

Levee design for the second planning iteration concentrated on various modifications of Measure 6. Although Measures 9, 10, and 11 include the same basic levee profiles as Measure 6, each has a different levee alignment as suggested by the Corps of Engineers and local officials.

9.1.1 Measures 9, 10, and 11

Measure 9 begins at the same upstream location as Measure 6 but avoids the agricultural land protected by the Ste. Genevieve County Levee District #2 (PLATE A-11). The upper half of the levee alignment is similar to Measure 6 but the lower half does not include protection to the sewage lagoon nor include drainage from Valle Spring Branch. The levee alignment for Measure 10 is similar to Measure 9 with the exception that Measure 10 includes the Valle Spring Branch watershed (PLATE A-12). Measure 11 has nearly the same levee alignment as Measure 6 but includes the additional drainage area of Valle Spring Branch (PLATE A-13).

9.2 INTERIOR DRAINAGE STUDY

An extensive interior drainage study was developed for Measure 9, as will be discussed later. Design features for Measures 10 and 11 were contingent on information from Measure 9.

9.2.1 Measure 9, 10, and 11

The interior drainage features for Measure 9 were determined from both a detailed hydrologic model and a period of record analysis. Pumping station size was based on a 10-year, 9-day duration rainfall at 60 minute intervals with blocked gravity drain conditions. Capacity of the pumping station was selected as that necessary to keep interior ponding elevations from reaching a minimum damage elevation of 382.5' NGVD. The pumping station capacity was verified with a period of record analysis using the St. Louis District Interior Drainage Program. Gravity drains were designed for unblocked conditions, and the peak discharge of a 10-year storm event routed through storage in the ponding areas. Measure 9 will be discussed at greater length in Section 11 - Selected Plan.

Design features for Measure 10 was based on results from Measure 9 but adjusted to account for the additional drainage area from Valle Spring Branch. Measure 11 included HEC-1 models similar in format to Measure 9 but reflected levee alignment similar to Measure 6 (i.e., additional drainage area from Valle Spring Branch and local interior plus

additional storage area south of the sewage lagoon). A summary of pumping station and gravity drains for Measures 9, 10 and 11 are shown on TABLE C-15.

Interior ditching for Measures 9, 10 and 11 were designed to provide adequate drainage of the interior system to the proposed pumping station and gravity drains. Ditching improvements were based on providing at least the same channel capacity as existing capacity assuming side slopes at 3:1. TABLE C-16 lists the interior ditching requirements necessary for Measures 9, 10 and 11.

9.3 TRIBUTARY FLOOD REDUCTION MEASURES

The second iteration examined in detail two flood reducing measures for each tributary: 1) Channel widening, and 2) clearing and snagging.

9.3.1 Measures 12 and 13

Measures 12 and 13 consisted of modifying the future without project HEC-2 models of South and North Gabouri Creeks, respectively, to reflect damage reduction due to channel widening (PLATE A-15). Building restrictions and bank confinement governed the selection of location and dimensions of the channel. Criteria for the channel widening measures included maintaining a bottom width equal to 30 feet with excavation on only one bank except for transitional reaches. The improved bank had

TABLE C-15

PUMPING STATION AND GRAVITY DRAIN SUMMARY - SECOND ITERATION

MEASURES 9, 10 and 11

Measure	Pumping Station Size	Gravity Drain Sizes GD1	GD2	GD3	Other
9	650cfs @ Gravity Drain GD2	2-72" dia x 370' CMP	5-10'dia x 418' CMP	2-36" dia x 290' CMP	1-36" dia x 100' CMP with flapgate. Required to drain subarea 930 to pumping station via South Gabouri Creek.
					2-24" dia x 20'CMP. Required to drain Mississippi Slough to pumping station via North Gabouri Creek @ low flows.
10	800cfs @ Gravity Drain GD2	2-72" dia x 370' CMP	6-10' dia x 418' CMP	-	2-24" dia x 20'CMP. Required to drain Mississippi Slough to pumping station via. North Gabouri Creek @ low flows.

TABLE C-15 (Continued)

PUMPING STATION AND GRAVITY DRAIN SUMMARY - SECOND ITERATION

MEASURES 9, 10, and 11

Measure	Pumping Station Size	Gravity Drain Sizes GD1	GD2	GD3	Other
11[2]	650cfs @ Gravity Drain GD2	2-72" dia x 370' CMP	5-10' dia x 418' CMP	-	1-36" dia x 100'CMP, and 1-36" dia x 200'CMP with flapgate. Both required to drain additional local storage area south of sewage lagoon to pumping station via Valle Spring Branch. 2-24" dia x 20'CMP. Required to drain Mississippi Slough to pumping station via North Gabouri Creek @ low flows.

1. Pumping station and gravity drain design for Measure 10 was based on increased percent drainage area from Valle Spring Branch.

2. Pumping station and gravity drain design for Measure 11 was based on HEC-1 model from Measure 9 modified to represent increased drainage area from Valle Spring Branch and increased storage area south of sewage lagoon.

TABLE C-16

INTERIOR DITCHING - SECOND ITERATION

MEASURES 9, 10 and 11

Measure	Ditch Location	Delivers Flow		Cross-sectional Dimensions	
		From	To	Bottom Width (ft)	Side Slopes
9	Approach ditch to gravity drain GD1	Mississippi Slough	Mississippi River	75	3:1
	Service road to local airport landing strip	Mississippi Slough	North Gabouri Creek	5	3:1
	Approach ditch to pumping station and gravity drain GD2	Gabouri Creek	Mississippi River	40	3:1
	Channel Cutoff along South Gabouri Creek	South Gabouri Creek	Gabouri Creek	40	3:1
	Landside toe of levee from GD3 to South Gabouri Creek	GD3	South Gabouri Creek	3	3:1

TABLE C-16 (Continued)

INTERIOR DITCHING - SECOND ITERATION

MEASURES 9, 10 and 11

Measure	Ditch Location	Delivers Flow		Cross-sectional Dimensions	
		From	To	Bottom Width (ft)	Side Slopes
10	Approach ditch to gravity drain GD1	Mississippi Slough	Mississippi River	75	3:1
	Service road to local airport landing strip	Mississippi Slough	NOrth Gabouri Creek	5	3:1
	Approach ditch to pumping station and gravity drain GD2	Gabouri Creek	Mississippi River	40	3:1
	Channel improvement along South Gabouri Creek	South Gabouri Creek and Valle Spring Br.	Gabouri Creek	40	3:1
	Channel realignment of Valle Spring Branch	Valle Spring Br.	South Gabouri Creek	30	3:1

TABLE C-16 (Continued)

INTERIOR DITCHING - SECOND ITERATION

MEASURES 9, 10 and 11

Measure	Ditch Location	Delivers Flow		Cross-sectional Dimensions	
		From	To	Bottom Width (ft)	Side Slopes
11	Approach ditch to gravity drain GD1	Mississippi Slough	Mississippi River	75	3:1
	Service road to local airport landing strip	Mississippi Slough	North Gabouri Creek	5	3:1
	Approach ditch to pumping station and gravity drain GD2	Gabouri Creek	Mississippi River	40	3:1
	Channel improvement along South Gabouri Creek	South Gabouri Creek and Valle Spring Br.	Gabouri Creek	40	3:1
	From St. Louis-San Francisco RR. to Valle Spring Branch	Ponding area south of sewage lagoon	Valle Spring Br.	5	3:1

side slopes 2:1 with riprap placed from the toe to approximately one-half the bank depth to minimize costs. The remainder of the improved bank, within a 50-foot easement, was assumed to be seeded with grass. The existing banks were protected with gabions to eliminate future erosion and sloughing problems. Minimum size riprap was used and considered adequate for velocities up to the 50-year recurrence interval. Roughness coefficients for riprap and gabions were 0.032 and 0.030, respectively. PLATE C-21 shows a typical cross-section with channel widening features for Measures 12 and 13. In areas with excavation near historical sites, gabions were used in lieu of riprap on the improved bank because of limited easement rights. Small levees along both creeks were evaluated in areas of low lying structures for added protection. Measure 13 will include a small levee built to 388 ft. NGVD along the right bank of North Gabouri Creek from RM 1.38 to RM 1.52. Assuming one foot for freeboard, the levee will provide a level of protection up to a 50-year recurrence interval for North Gabouri Creek floods although a higher level may be achieved along the lower reaches of the levee alignment. Measure 12 also proposes a small levee from RM 1.35 to RM. 1.63 along the left bank of South Gabouri built to 385 ft. NGVD. This levee will provide protection up to 10-year recurrence interval South Gabouri Creek flood, assuming one foot freeboard. Similar to North Gabouri Creek, structures on the left bank of South Gabouri Creek along the lower reaches of the levee alignment may achieve a higher level of protection. Bridges for both measures were removed or cleaned out as necessary to reduce flood heights. TABLE C-17 lists the improvement features for Measures 12 and 13.

TABLE C-17
IMPROVEMENT FEATURES
FOR MEASURES 12 AND 13

North Gabouri Creek (Measure 13)

Reach (Stream Miles)	Improvement Feature	Right or Left Bank	Bridge Replacement	Bridge Cleaning
1.26 - 1.45	Channel Widening	Left	Main St.	-
1.38 - 1.52	Levee	Right	-	-
1.43 - 1.75	Channel Widening	Right	Fourth St.	Third St.
1.74 - 1.88	Channel Widening	Left	-	-

South Gabouri Creek (Measure 12)

Reach (Stream Miles)	Improvement Feature	Right or Left Bank	Bridge Replacement	Bridge Cleaning
1.35	-	-	-	St.L.-SF.RR.
1.35 - 1.39	Channel Widening	Right	-	-
1.35 - 1.93	Channel Widening	Left	Third St. (Wooden Br.)	Main St. Mo.-Il.RR. Fourth St.
1.35 - 1.63	Levee	Left	-	-
1.65	Partial Road Raise of S. Gabouri St. east of Main St.	Left	-	-
1.88 - 2.58	Channel Widening	Right	Seventh St. Tenth St.	Mo.-Il.RR.

9.3.2 Measure 18 and 19

Measures 18 and 19 included a clearing and snagging operation along South and North Gabouri Creeks, respectively, as shown on PLATE A-14. Clearing and snagging is basically a flood reducing measure to lower flood heights by removing debris from the existing channel. Measure 18 consists of clearing and snagging along South Gabouri Creek from the Missouri-Illinois R.R. (RM 1.69) to an area near the Knights of Columbus building (RM 2.1). Measure 19 included clearing and snagging along North Gabouri Creek from the Missouri-Illinois and St. Louis-San Francisco Railroads (RM 1.26) to the Third Street bridge (RM 1.49). Roughness coefficients for each measure was 0.030 and 0.040 for the channel and overbank, respectively.

SECTION 10 - OTHER MEASURES EXAMINED

10.1 DETENTION SITES

As mentioned earlier, a total of seven dry detention sites were initially investigated - five along North Gabouri Creek and two on South Gabouri Creek. However, detention dams/reservoirs on either stream were eliminated from further study due to subsurface unstabilities, construction costs, soil/foundation problems, and the need for extensive sub-surface exploration.

10.2 BRIDGE REMOVAL/CLEARING AND SNAGGING

The reduction to future without project profiles for North and South Gabouri Creeks were evaluated by removing certain bridges, clearing and snagging or some combination of both. The North Gabouri Creek model was independently modified to reflect each of the following conditions: 1) Removing Main St. bridge, 2) Removing Third St. bridge, 3) Removing Fourth St. bridge, 4) Clearing and snagging between miles 1.26 and 1.49, 5) Clearing and snagging between miles 1.26 and 1.49 and removal of Main St. bridge, and 6) Clearing and snagging between miles 1.26 and 1.49 and removal of Third St. bridge. Separate HEC-2 models for South Gabouri Creek were also run to simulate: 1) Removal of Fourth St. bridge, 2) Removal of Fourth St. bridge and fill material in floodway, 3) Clearing and snagging between miles 1.69 and 2.1, and 4) Clearing and snagging between miles 1.69 and 2.1 and removal of Fourth St. bridge and fill material in the floodway. TABLE C-18 lists each alternative measure for North and South Gabouri Creeks, the corresponding reach length affected by each measure, and the approximate maximum flood reduction for the 10-year recurrence interval flood.

SECTION 11 - SELECTED PLAN

The selected plan, Plan 1, for minimizing flood damages to the City of Ste. Genevieve includes a combination of several previous measures (PLATE A-18). Plan 1 consisted of the levee alignment and interior

TABLE C-18

BRIDGE REMOVAL/CLEARING AND SNAGGING MEASURES

NORTH AND SOUTH GABOURI CREEKS

North Gabouri Creek

Measure	Reach Affected	10-Yr. Recurrence Interval Approx. Maximum Flood Reduction
Removal of Main St. Bridge	RM 1.3 - RM 1.45	-0.2
Removal of Third St. Bridge	RM 1.49 - RM 1.73	-0.4
Removal of Fourth St. Bridge	RM 1.61 - RM 1.83	-0.3
Clearing and Snagging		
(RM 1.26 - RM 1.49):	RM 1.26 - RM 1.49	-1.5
w/removal of Main St. Br.	RM 1.26 - RM 1.49	-1.6
w/removal of Third St. Br.	RM 1.26 - RM 1.71	-1.6

South Gabouri Creek

Measure	Reach Affected	10-Yr. Recurrence Interval Approx. Maximum Flood Reduction
Removal of Fourth St. Bridge	RM 1.9 - RM 1.96	-0.1
Removal of Fourth St. Bridge and Bridge Fill Material	RM 1.9 - RM 2.12	-0.6
Clearing and Snagging		
(RM 1.69 - RM 2.1):	RM 1.69 - RM 2.2	-1.0
w/removal of Fourth St. Br. and Bridge Fill Material	RM 1.69 - RM 2.2	-1.1

drainage system from Measure 9 and flood reduction measures from Measures 12 and 13. Three feet for freeboard will be added to the riverfront levee system to protect the City of Ste. Genevieve from wave action, temporary changes in stage-discharge relationships, and other factors.

11.1 INTERIOR DRAINAGE DESIGN

A detailed interior drainage study was performed for Measure 9. Local interior subareas contained by the levee alignment of Measure 9 were subdivided into three separate subareas, 910, 920 and 930, each with gravity drainage at GD1, GD2, and GD3; respectively (PLATE C-22). All three subareas were combined (subarea 900) to represent the total available storage for the pumping station analysis. The pumping station was sited at gravity drain GD2.

The interior drainage study consisted of developing HEC-1 computer models to determine the initial facility sizes and verifying the selected sizes with the St. Louis District Interior Drainage Program. PLATE C-23 illustrates a schematic of the pumping station and gravity drain HEC-1 models at outlet GD2. PLATE C-24 shows a schematic of the HEC-1 models for gravity drains GD1 and GD3. Basin characteristics of each subarea for Measure 9 are listed on TABLE C-19. PLATE C-25 illustrates the

TABLE C-19

BASIN CHARACTERISTICS OF

SUBAREAS FOR MEASURE 9

Subarea No.	Local Drainage Area (sq. mi.)	tt[2] (hrs.)	SCS lag[3] (hrs.)
75	6.01	1.55	0.93
95	1.42	1.00	0.60
125	5.55	2.08	1.25
155	0.68	0.37	0.22
900[1]	1.518	1.61	0.96
910[1]	0.693	1.44	0.86
920[1]	0.575	0.56	0.34
930[1]	0.250	0.27	0.32[4]

1) Subareas Nos. 910, 920, and 930 are drained by gravity at outlet locations GD1, GD2, and GD3, respectively. Subarea 900 (for pumping station design) equals the sum of local subareas 910, 920, and 930, and drained at outlet location GD2.

2) Travel Time (hours) = $(11.9L^3/H)^{.385}$, *where* L = *total* length in miles and H = height in feet.

3) SCS lag = 0.6 tt

4) For overland flow, SCS lag doubled: .6(.27) x 2 = 0.32.

elevation-storage curves used in the HEC-1 models for each gravity drain and the pumping station. The storage area for each gravity drain was assumed independent of other subareas up to a selected critical elevation. When interior ponded waters exceeded the critical elevations, overtopping would result and include additional storage from the adjacent subarea(s). The interior storage areas for gravity drains GD1, GD2, and GD3 are GD1STOR, GD2STOR, and GD3STOR; respectively. The critical elevations between storage areas was calculated to be 378 feet NGVD for GD1STOR and GD2STOR and 382 feet NGVD for GD2STOR and GD3STOR. The available storage area for the pumping station (PSSTOR) was the sum of the storage areas of each gravity drain. All storage curves are considered conservative since they do not reflect additional storage from possible borrow pits excavated for levee construction.

Land use maps supplied by the Southeast Missouri Regional Planning and Economic Development Commission and soil maps by the Soil Conservation Service were used to determine existing and future conditions for each subarea of Measure 9. Land use, soil group and weighted SCS curve numbers are summarized in TABLES C-20 and C-21 for existing and future conditions, respectively.

11.1.1 Pumping Station Analysis

The pumping station capacity of Measure 9 was evaluated based on various hypothetical floods using 9-day duration storms with 60 minute intervals and blocked gravity drain conditions. As indicated by the

TABLE C-20

LAND USE FOR

MEASURE 9

EXISTING CONDITIONS

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	"C"	"D"	% Hydrologic Soil Group "B"	"C"	"D"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
75	Cropland and Pasture	3.40	70	77	80	84%	16%	-	71.1	56.5%	
	Decideous Forest Land	2.61	60	73	80	84%	16%	-	62.1	43.5%	
		6.01 sq. mi.									67
95	Residential	.65	75	83	87	100%	-	-	75	46.0%	
	Commercial	.03	92	94	95	100%	-	-	92	2.0%	
	Cropland and Pasture	.68	70	77	80	100%	-	-	70	48.0%	
	Decideous Forest Land	.06	60	73	80	100%	-	-	60	4.0%	
		1.42 sq. mi.									72
125	Industrial	.17	88	91	93	87%	13%	-	88.4	3.0%	
	Cropland and Pasture	2.50	70	77	80	87%	13%	-	70.9	45.0%	
	Decideous Forest Land	2.61	60	73	80	87%	13%	-	61.7	47.0%	
	Reservoirs	.05	100	100	100	87%	13%	-	100	1.0%	
	Mines, Quarries, Gravel Pits	.22	50	50	50	87%	13%	-	50	4.0%	
		5.55 sq. mi.									66
155	Residential	.32	75	83	87	100%	-	-	75	47.0%	
	Commercial	.07	92	94	95	100%	-	-	92	10.0%	
	Industrial	.05	88	91	93	100%	-	-	88	7.0%	
	Mixed Urban	.02	77	82	85	100%	-	-	77	3.0%	
	Other Urban	.02	77	82	85	100%	-	-	77	3.0%	
	Cropland and Pasture	.15	70	77	80	100%	-	-	70	23.0%	
	Transitional Areas	.05	65	65	65	100%	-	-	65	7.0%	
		.68 sq. mi.									76

TABLE C-21

LAND USE FOR

MEASURE 9

FUTURE CONDITIONS

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	SCS Curve No. "D"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	% Hydrologic Soil Group "D"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
75	* * * * * * * * * * * * Same as Existing Conditions * * * * * * * * * * * *										67
95	Residential	.95	75	83	87	100%	-	-	75	67.0%	
	Commercial	.07	92	94	95	100%	-	-	92	5.0%	
	Mixed or Other Urban	.06	77	82	85	100%	-	-	77	4.0%	
	Cropland and Pasture	.31	70	77	80	100%	-	-	70	22.0%	
	Decideous Forest Land	.03	60	73	80	100%	-	-	60	2.0%	
		1.42 sq. mi.									75
125	Residential	.39	78	83	87	87%	13%	-	76.0	7.0%	
	Commercial	.06	92	94	95	87%	13%	-	92.3	1.0%	
	Industrial	1.11	88	91	93	87%	13%	-	88.4	20.0%	
	Mixed or Other Urban	.06	77	82	85	87%	13%	-	77.7	1.0%	
	Cropland and Pasture	1.83	70	77	80	87%	13%	-	70.9	33.0%	
	Decideous Forest Land	.83	60	73	80	87%	13%	-	61.7	15.0%	
	Reservoirs	.27	100	100	100	87%	13%	-	100.0	5.0%	
	Mines, Quarries, Gravel Pits	1.00	50	50	50	87%	13%	-	50.0	18.0%	
		5.55 sq. mi.									71
155	Residential	.40	75	83	87	100%	-	-	75	59.0%	
	Commercial	.09	92	94	95	100%	-	-	92	13.0%	
	Industrial	.07	88	91	93	100%	-	-	88	10.0%	
	Mixed or Other Urban	.06	77	82	85	100%	-	-	77	8.0%	
	Cropland and Pasture	.06	70	77	80	100%	-	-	70	8.0%	
		.68 sq. mi.									77

TABLE C-21 (Continued)

LAND USE FOR

MEASURE 9

FUTURE CONDITIONS

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	SCS Curve No. "D"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	% Hydrologic Soil Group "D"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
900	Residential	.501	75	83	87	85%	3%	12%	77	33.0%	
	Commercial	.106	92	94	95	85%	3%	12%	92	7.0%	
	Industrial	.106	88	91	93	85%	3%	12%	89	7.0%	
	Mixed or Other Urban	.197	77	82	85	85%	3%	12%	78	13.0%	
	Cropland and Pasture	.577	70	77	80	85%	3%	12%	71	38.0%	
	Decideous Forest Land	.031	60	73	80	85%	3%	12%	63	2.0%	
		1.518 sq. mi.									77
910	Residential	.145	75	83	87	100%	-	-	75	21.0%	
	Commercial	.042	92	94	95	100%	-	-	92	6.0%	
	Mixed or Other Urban	.159	77	82	85	100%	-	-	77	23.0%	
	Cropland and Pasture	.319	70	77	80	100%	-	-	70	46.0%	
	Decideous Forest Land	.028	60	73	80	100%	-	-	60	4.0%	
		.693 sq. mi.									74
920	Residential	.230	75	83	87	99%	-	1%	75.1	40.0%	
	Commercial	.029	92	94	95	99%	-	1%	92.0	5.0%	
	Industrial	.080	88	91	93	99%	-	1%	88.1	14.0%	
	Mixed or Other Urban	.086	77	82	85	99%	-	1%	77.1	15.0%	
	Cropland and Pasture	.138	70	77	80	99%	-	1%	70.1	24.0%	
	Decideous Forest Land	.012	60	73	80	99%	-	1%	60.2	2.0%	
		.575 sq. mi.									77

TABLE C-21 (Continued)

LAND USE FOR

MEASURE 9

FUTURE CONDITIONS

Subarea No.	Land Use	Area (sq. mi.)	SCS Curve No. "B"	SCS Curve No. "C"	SCS Curve No. "D"	% Hydrologic Soil Group "B"	% Hydrologic Soil Group "C"	% Hydrologic Soil Group "D"	Weighted Curve No. Based On Hydrologic Soil Group	% Land Use	Final Weighted Curve No.
930	Residential	.078	75	83	87	43%	10%	47%	81	31.0%	
	Commercial	.027	92	94	95	43%	10%	47%	94	11.0%	
	Cropland and Pasture	.145	70	77	80	43%	10%	47%	75	58.0%	
		.250 sq. mi.									79

schematic on PLATE C-23, the HEC-1 model was developed by combining the local interior hydrograph from subarea 900 with hydrographs from North and South Gabouri Creek and routing the combined hydrograph through the available storage area. The only flow allowed to leave the system was via pumpage.

Similar to the initial studies of Measure 5 through 8, a multi-plan HEC-1 computer model was run with pumping capacities of no pump, 250 cfs, 500 cfs, 750 cfs and 1000 cfs and start/stop elevations of each plan at 376'/374' NGVD. The maximum ponding elevation was selected as 382.5' NGVD based on maximum storage potential with minimal damage to structures located near the ponding area. Structure #86 was the only building flooded by interior ponding at a damage elevation of 381.4' NGVD. The recommended pumping station capacity of 650 cfs was selected from the elevation-pumping capacity curve for the 10-year recurrence interval, based on preventing ponded water from exceeding 382.5' NGVD.

Next, the total capacity of the pumping station was sub-divided into three smaller pumps of 100 cfs, 250 cfs and 300 cfs capacity with start/stop elevations of 374/373, 375/374, and 376/375, respectively. At least three pumps would be necessary to make up the total capacity. The staggered start/stop elevations for each pump are based on maintaining interior ponding stages less than 382.5 feet NGVD. TABLE C-22 summarizes the recommended pumping station capacity for Measure 9.

TABLE C-22

PUMPING STATION AND GRAVITY DRAIN SUMMARY

MEASURE 9

PUMPING STATION DATA

(Blocked Gravity Drain Conditions)

Outlet Location	Total D.A.(sq.mi.)	10-yr. Storm Duration	10-yr. Storm Interval	Pumping Station Capacity Start/Stop Elev. (ft. NGVD)	Pumping Station Capacity Pump Capacity (cfs)
GD2	15.178	216 hr.	60 min.	374.0/373.0	100
				375.0/374.0	250
				376.0/375.0	300

Total Capacity = 650 cfs

GRAVITY DRAIN DATA

(Unblocked Gravity Drain Conditions)

Outlet Location	Total D.A.(sq.mi.)	10-yr. Storm Duration	10-yr. Storm Interval	Maximum Ponding Elev. (ft. NGVD) Without Drains	Maximum Ponding Elev. (ft. NGVD) With Drains	Gravity Drain Dimensions
GD1	0.693	48 hr.	10 min.	375.85	374.02	2-72" dia. x 370' CMP's
GD2	14.235	96 hr.	20 min.	385.1[illegible]	377.75	5-10' dia. x 418' CMP's
GD3	0.250	24 hr.	5 min.	380.32	379.81	2-36" dia. x 290' CMP's

11.1.2 Gravity Drain Analyses

Three gravity drains are needed for Measure 9 to drain approximately 15.2 sq. mi. of hillside and local runoff. Gravity drain GD2 is located along Gabouri Creek and drains both Gabouri Creeks as well as some local runoff. Gravity drains GD1 and GD3 remove mostly local runoff. Each gravity drain was designed for a peak 10-year storm event with unblocked drain conditions. Separate storage elevation curves were developed for each drain, as shown on PLATE C-25. Critical elevations between subareas were based on the lowest elevation of drainage divides between storage areas. All gravity drains were assumed to be corrugated metal pipe (CMP) and lined with asphalt to maximize hydraulic efficiency and minimize pipe size. CMP's were preferred over concrete box culverts since they are readily available and easily placed in field construction. The maximum standard pipe size of 10-foot diameter were used because special gate structures are needed for larger size diameter pipes. Gravity drain GD2 was reanalyzed based on multiple 10-foot diameter CMP's rather than multiple concrete box culvert (as in Measures 6 and 8 of the first iteration).

Initial gravity drain sizes were estimated based on the peak 10-year discharge from the HEC-1 models before being routed through the available storage area at each site. Rating curves at the inlets of each gravity drain were developed from the St. Louis District 'CULVERT' program based

on the initial gravity drain sizes. The HEC-1 models were then rerun for the 10-year storm and routed through bottomland storage using the rating curve at each site for a constant tailwater at one-half the pipe diameter. TABLE C-22 summarizes the maximum ponding elevations expected with and without gravity drains GD1, GD2 and GD3 for the 10-year recurrence interval flood. PLATES C-25A and C-25B illustrate the discharge and stage hydrographs at site location GD2 for with and without gravity drains in place. Hydrographs at GD1 and GD3 produced similar results.

11.1.3 Period of Record Analysis

A period of record analysis was developed for Measure 9 as part of the interior drainage study to verify capacities of design features from the HEC-1 models. Major consideration was given to the pumping station and gravity drains at GD2. The period of record analysis featured daily routings of rainfall and seepage to further evaluate Measure 9.

The period of record included daily stages from 1939 to 1982 at Chester, Illinois and daily rainfall for the same period at Sparta, Illinois. A river transfer curve was constructed at the outlet of each gravity drain site based on the Mississippi River slope profiles adjusted from the Chester gage (RM 109.9). An agricultural monthly runoff factor provided daily inflow values for interior routing. The interior ponding

elevations developed at each gravity drain location reflected 24-hour values, although instantaneous peak stages may be higher due to flash flooding. An automatic warning system to operate the pumping station will be investigated in the pre-construction phase to prevent potential flood damages within the ponding area.

Results from the period of record analysis showed that a 650 cfs capacity pumping station is sufficient. PLATE C-25C shows the stage-hydrograph at GD2 taken from the interior drainage program for the April-May 1973 flood comparing stages on the Mississippi River and the interior ponding stages with a 650 cfs pumping station in operation. PLATE C-25C also illustrates daily local rainfall values and the 24 hour volumes pumped from the interior ponding area.

11.1.4 Interior Stage-Frequency Relationship

A composite interior ponding stage-frequency curve was developed for Measure 9 at location GD2. A multi-ratio HEC-1 model for blocked and unblocked conditions was used to determine the maximum ponding level for the 25-, 50-, 100- and 500-year recurrence interval floods with the 10-year as the base flood (PLATE C-26). Blocked gravity drain conditions were assumed to occur when the Mississippi River rose to elevations greater than one-half the outlet pipe diameter (367.5 ft. NGVD). River stages exceeding this elevation at GD2 occurred 14.1 percent of the time

and, conversely, unblocked conditions occurred 85.9 percent of the time. A simplified version of the total probability theorem was then used to develop a combined stage-frequency between the blocked and non-blocked conditions; however, stages appeared too low for events less than the 50-year recurrence interval flood. Consequently, results from the period of record analysis were used for the more frequent events by plotting the annual high interior stages by the Weibull Plotting Method (TABLE C-23). The adopted interior ponding stage-frequency curve thus linked together the period of record with a combined frequency analysis for blocked and unblocked conditions. The adopted curve for Measure 9 at GD2 is shown on PLATE C-26.

11.2 IMPACTS OF SELECTED PLAN

The proposed project will have minimal impacts on flood heights of the Mississippi River. Induced damages at the Little Rock Landing gage (RM 125.5) for Measure 9 is shown on PLATE C-26A. Impacts further upstream at the Brickey's Landing gage (RM 136.0) are negligible (less than 0.3 foot) through the 100-year recurrence interval event. The agricultural floodplain within Measure 9 will serve as ponding areas for both Gabouri Creeks and local runoff. The available storage area is needed to minimize pumping station capacity and should not be encroached on in future years. Velocity increases due to the proposed channel cutoff at South Gabouri Creek will be about 1 to 2 feet per second and

TABLE C-23
WEIBULL PLOTTING POSITIONS FOR
INTERIOR STAGES
MEASURE 9
1939 TO 1982

Calendar Year	Peak Interior Stage (Ft. NGVD)	Rank	Calendar Year	Peak Interior Stage (Ft. NGVD)	Weibull Plot Pos.
1939	378.6	1	1969	382.5	.022
1940	370.0	2	1981	381.5	.044
1941	381.1	3	1961	381.3	.066
1942	379.4	4	1941	381.1	.088
1943	379.2	5	1952	380.7	.111
1944	380.0	6	1982	380.4	.133
1945	379.8	7	1966	380.4	.155
1946	379.4	8	1962	380.2	.177
1947	378.1	9	1979	380.1	.200
1948	378.7	10	1944	380.0	.222
1949	378.3	11	1957	380.0	.244
1950	378.7	12	1972	380.0	.266
1951	379.4	13	1975	380.0	.288
1952	380.7	14	1945	379.8	.311
1953	378.5	15	1965	379.6	.333
1954	378.5	16	1970	379.5	.355
1955	378.8	17	1942	379.4	.377
1956	370.0	18	1946	379.4	.400
1957	380.0	19	1951	379.4	.422

TABLE C-23 (Cont'd)
WEIBULL PLOTTING POSITIONS FOR
INTERIOR STAGES
MEASURE 9
1939 TO 1982

Calendar Year	Peak Interior Stage (Ft. NGVD)	Rank	Calendar Year	Peak Interior Stage (Ft. NGVD)	Weibull Plot Pos.
1958	378.3	20	1943	379.2	.444
1959	377.8	21	1973	379.1	.466
1960	378.7	22	1978	379.0	.488
1961	381.3	23	1967	378.9	.511
1962	380.2	24	1955	378.8	.533
1963	377.6	25	1974	378.8	.555
1964	375.8	26	1948	378.7	.577
1965	379.6	27	1950	378.7	.600
1966	380.4	28	1960	378.7	.622
1967	378.9	29	1968	378.7	.644
1968	378.7	30	1977	378.7	.666
1969	382.5	31	1939	378.6	.688
1970	379.5	32	1953	378.5	.711
1971	378.1	33	1954	378.5	.733
1972	380.0	34	1976	378.5	.755
1973	379.1	35	1958	378.3	.777
1974	378.8	36	1949	378.3	.800
1975	380.0	37	1947	378.1	.822
1976	378.5	38	1971	378.1	.844

TABLE C-23 (Cont'd)
WEIBULL PLOTTING POSITIONS FOR
INTERIOR STAGES
MEASURE 9
1939 TO 1982

Calendar Year	Peak Interior Stage (Ft. NGVD)	Rank	Calendar Year	Peak Interior Stage (Ft. NGVD)	Weibull Plot Pos.
1977	378.7	39	1980	377.9	.866
1978	379.0	40	1959	377.8	.888
1979	380.1	41	1963	377.6	.911
1980	377.9	42	1964	375.8	.933
1981	381.5	43	1940	370.0	.955
1982	380.4	44	1956	370.0	.977

will require riprap protection. Riprap protection is also required at the outlets of each gravity drain and along the Valle Spring Branch diversion.

11.3 FUNCTIONAL OPERATION

The proposed project will function as intended, with necessary operation and maintenance. The levee system should be inspected at least annually to ensure its safety and integrity. The pumping station and gravity drains should be inspected periodically to assure proper operation. During flood conditions from the Mississippi River, installation of three closure structures will be required along the riverfront levee. The closure structures shall be stored in the levee district with several days of warning time available for their installation.

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

APPENDIX D

DESIGN AND COST ESTIMATES

STE. GENEVIEVE, MISSOURI

APPENDIX D

DESIGN AND COST ESTIMATES

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APPENDIX D

DESIGN AND COST ESTIMATES

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STE. GENEVIEVE, MISSOURI

APPENDIX D

DESIGN AND COST ESTIMATES

SECTION 1 - PURPOSE

The purpose of this appendix is to present a summary of the detailed design and cost estimates accomplished for the Ste. Genevieve study. These design and cost estimates are based on October 1982 price levels.

The designs for the various structural and non-structural components were based on the best available data, field investigations, and current design procedures. In some instances, the use of engineering judgment was necessary due to the absence of readily available data.

The real estate requirements for the various designs and components were determined and coordinated with the St. Louis District, Corps of Engineers, Real Estate Division.

SECTION 2 - PUBLIC SAFETY CONSIDERATIONS

The design of the project components comply with all applicable Corps of Engineers guidance, codes and regulations.

SECTION 3 - COST ESTIMATES FOR PLANS

During plan formulation, numerous plans were considered and developed. From these, four plans are being carried forward in this report. These plans are:

Plan No. 1. Selected Plan

Plan No. 2. Plan by Others

Plan No. 3. Environmental Quality

Plan No. 4. National Economic Development

The summarized first costs for each of the plans identified above are shown in TABLE D-1 consistent with the traditional costs sharing policy.

SECTION 4 -
SELECTED PLAN
DETAILED COST ESTIMATE

4.1 FEDERAL COST

The specific line item estimated Federal construction costs for the selected plan based on traditional cost apportionment and October 1982 price levels are shown in TABLE D-2. For typical cross sections of the "Urban Design Levee" and "Tributary Channel Widening" see PLATES 10 and 11 in the MAIN REPORT.

TABLE D-1
SUMMARY OF FIRST COSTS
STE. GENEVIEVE
OCTOBER 1982 PRICE LEVEL

FEDERAL COSTS	PLAN No. 1	PLAN No. 2	PLAN No. 3	PLAN No. 4
09 CHANNEL AND CANALS	$ 2,900,000	$ 2,950,000	$ 2,920,000	$ 16,000
11 LEVEE AND FLOODWALLS	15,800,000	16,430,000	15,990,000	250,000
13 PUMPING PLANT	5,500,000	6,250,000	5,500,000	-0-
14 RECREATION	60,000	60,000	60,000	-0-
30 ENGINEERING AND DESIGN	3,000,000	3,070,000	2,960,000	40,000
31 SUPERVISION AND ADMINISTRATION	1,840,000	1,7[illegible]0,000	1,770,000	24,000
TOTAL FEDERAL COST	$29,100,000	$30,500,000	$29,200,000	$330,000
NON-FEDERAL COST				
01 LANDS AND DAMAGES	$ 940,000	$ 1,011,000	$ 1,158,000	$ 13,000
02 RELOCATIONS	1,190,000	1,171,000	1,077,000	-0-
11 LEVEE AND FLOODWALLS	-0-	-0-	-0-	50,000
14 RECREATION	60,000	60,000	60,000	-0-
30 ENGINEERING AND DESIGN	150,000	150,000	138,000	10,000
31 SUPERVISION AND ADMINISTRATION	60,000	108,000	67,000	7,000
TOTAL NON-FEDERAL COST	$ 2,400,000	$ 2,500,000	$ 2,500,000	$ 80,000
TOTAL PLAN COSTS	$31,500,000	$33,000,000	$31,700,000	$410,000

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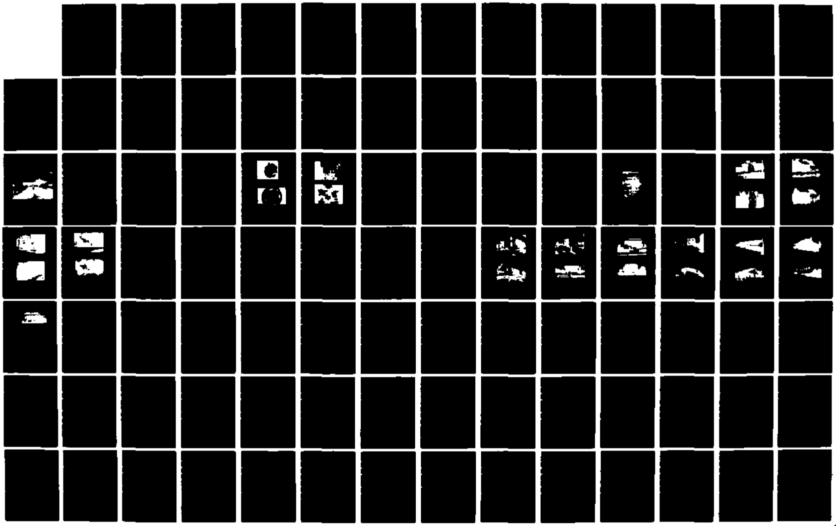

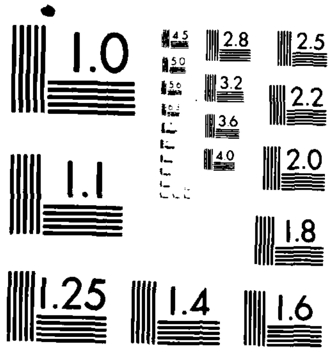

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TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
09	CHANNELS AND CANALS				($2,900,000)
	Channel Widening-South Gabouri Creek:				
	Excavation-Earth	45,000	C.Y.	$ 5.00	$ 225,000
	Excavation-Rock	8,000	C.Y.	15.00	120,000
	Granular Backfill	5,000	C.Y.	15.00	75,000
	Gabions	10,900	C.Y.	75.00	817,500
	Riprap - 150 lb. Topsize	3,000	Ton	20.00	60,000
	Bedding Material	1,500	Ton	18.00	27,000
	Clearing	9	Acre	1500.00	13,500
	Seeding	2	Acre	1000.00	2,000
	Embankment-Small Levee	1,000	C.Y.	4.00	4,000
	36 inch dia CMP-Small Levee	28	L.F.	40.00	1,120
	Subtotal for South Gabouri Creek				$1,345,120
	Contingencies				334,880
	Total for South Gabouri Creek				$1,680,000

TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
09	CHANNELS AND CANALS (cont'd)				
	Channel Widening - North Gabouri Creek:				
	Excavation-Earth	24,000	C.Y.	$ 5.00	$ 120,000
	Excavation-Rock	4,000	C.Y.	15.00	60,000
	Granular Backfill	2,700	C.Y.	15.00	40,500
	Gabions	3,700	C.Y.	75.00	277,500
	Riprap - 150 lb. Topsize	2,400	Ton	20.00	48,000
	Bedding Material	1,200	Ton	18.00	21,600
	Clearing	5	Acre	1500.00	7,500
	Seeding	1	Acre	1000.00	1,000
	Embankment-Small Levee	2,000	C.Y.	4.00	8,000
	Gravity Drain-Small Levee:				
	48 inch dia CMP	34	L.F.	50.00	1,700
	Concrete	5	C.Y.	30.00	150
	Riprap	40	Ton	20.00	800
	Bedding	20	Ton	20.00	400
	Subtotal for North Gabouri Creek				$587,150
	Contingencies				142,850
	Total for North Gabouri Creek				$730,000

TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
09	CHANNELS AND CANALS (cont'd.)				
	Channel Degrading for Interior Drainage:				
	Excavation	185,000	C.Y.	$ 2.00	$370,000
	Seeding	12	Acre	1000.00	12,000
	36 inch dia CMP w/gate	100	L.F.	33.00	3,300
	24 inch dia CMP	40	L.F.	50.00	2,000
	Channel Fill	4,000	C.Y.	2.00	8,000
	Subtotal for Interior Drainage				$ 395,300
	Contingencies				94,700
	Total for Interior Drainage				$ 490,000
	TOTAL FOR CHANNELS AND CANALS				$2,900,000
11	LEVEES AND FLOODWALLS				($15,800,000)
	Gravity Drains:				
	GD-1				
	72 inch dia CMP	740	L.F.	350.00	259,000
	Riprap-500 lb. Topsize	600	Ton	20.00	12,000
	Bedding Material	300	Ton	20.00	6,000
	Gates, Sluice	2	Ea.	100,000	200,000
	GD-2				
	120 inch dia CMP	2,090	L.F.	400.00	836,000
	Riprap - 500 lb. Topsize	16,000	Ton	20.00	320,000
	Bedding Material	8,000	Ton	20.00	160,000
	Gates, Sluice	5	Ea.	100,000	500,000

TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
11	LEVEES AND FLOODWALLS (cont'd.)				
	GD-3				
	36 inch dia CMP	580	L.F.	$330.00	$ 191,400
	Riprap	300	Ton	20.00	6,000
	Bedding Material	150	Ton	20.00	3,000
	Gates, Sluice	2	Ea.	10,000	20,000
	Gates, Flap	2	Ea.	15,000	30,000
	Embankment-Dredged	2,039,000	C.Y.	3.00	6,117,000
	Embankment - Clay	530,000	C.Y.	3.00	1,590,000
	Clearing - Levee	159	Acre	500.00	79,500
	Clearing - Borrow	83	Acre	1000.00	83,000
	Seeding	242	Acre	1000.00	242,000
	Excavation	50,000	C.Y.	2.00	100,000
	Road Stone - 1/2 inch	6,400	Ton	10.00	64,000
	Riprap	1,500	Ton	20.00	30,000
	Bedding Material	750	Ton	20.00	15,000
	Closure Structures:				
	N. Main Street (2 lane)	1	Ea.	560,000	560,000
	Railroad Track (Double Track) (@ N. Main St.)	1	Ea.	430,000	430,000
	Railroad Track (Single Track)	1	Ea.	300,000	300,000
	Highway 61 (2 lane)	1	Ea.	520,000	520,000
	SUBTOTAL FOR LEVEES AND FLOODWALLS				$12,673,900
	Contingencies				3,126,100
	TOTAL FOR LEVEES AND FLOODWALLS				$15,800,000

TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
13	PUMPING PLANT				($5,500,000)
	650 cfs Pump Station	SUM	JOB		$4,400,000
	Subtotal for Pump Station				4,400,000
	Contingencies				1,100,000
	TOTAL FOR PUMPING PLANT				$5,500,000
14	RECREATION				($60,000)
	North Gabouri Creek: River Mile 1.32 - 1.42 (Left Bank)				
	Picnic Tables	2	Ea.	$350.00	$ 700
	Bike Rack	1	Ea.	500.00	500
	Foot Bridge	1	Ea.	4000.00	4,000
	River Mile 1.42 - 1.62 (Right Bank)				
	Excavation	1,500	C. Y.	3.00	4,500
	Embankment	1,200	C. Y.	5.00	6,000
	Clearing	1	Acre	500.00	500
	Asphalt	700	Sq.Yd.	12.00	8,400
	Base Course	65	Tons	20.00	1,300
	Seeding	3	Acre	1200.00	3,600
	Bark Mulch	670	Sq.Yd.	10.00	6,700
	Baseball Back-Stop	45	L.F.	30.00	1,350
	Picnic Tables	6	Ea.	350.00	2,100
	Bike Rack	1	Ea.	500.00	500

TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
14	RECREATION (cont'd)				
	River Mile 1.62 - 1.93 (Left Bank)				
	Foot Bridge	1	Ea.	$3000.00	$ 3,000
	Asphalt	1780	Sq. Yd.	12.00	21,360
	Base Course	450	Ton	15.00	6,750
	South Gabouri Creek: River Mile 1.51 - 1.65				
	Picnic Tables	5	Ea.	350.00	1,750
	Bike Rack	1	Ea.	500.00	500
	Asphalt	420	Sq. Yd.	12.00	5,040
	Base Course	110	Ton	15.00	1,650
	River Mile 1.65 - 1.91				
	Asphalt	770	Sq. Yd.	12.00	9,240
	Base Course	200	Ton	15.00	3,000
	River Mile 1.91 - 2.45				
	Picnic Tables	5	Ea.	350.00	1,750
	Baseball Back Stop	45	L.F.	30.00	1,350
	Clearing	1	Acre	1000.00	1,000
	Seeding	3	Acre	1200.00	3,600
	Subtotal				100,140
	Contingencies				19,860

TABLE D-2
STE. GENEVIEVE
SELECTED PLAN
FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
14	RECREATION (cont'd)				
	TOTAL RECREATION				$ 120,000
	50% Non-Federal				
	50% Federal				
	TOTAL NON-FEDERAL COST				$ 60,000
	TOTAL FEDERAL COST				$ 60,000
30	ENGINEERING AND DESIGN COST				($3,000,000)
31	SUPERVISION AND ADMINISTRATION				($1,840,000)
	TOTAL FEDERAL COSTS FOR SELECTED PLAN				$29,100,000

4.2 NON-FEDERAL COST

The specific line item estimated non-Federal construction costs for the selected plan based on traditional cost apportionment and October 1982 price levels are shown in TABLE D-3.

SECTION 5 - OPERATION AND MAINTENANCE

Maintenance would include adequate measures to insure that the project objectives are maintained for the duration of the project life. Project components and their annual maintenance costs are shown in TABLE D-4. The annual maintenance costs include, but are not limited to, the following items of work: grass mowing, trash and debris removal, crushed stone repair, embankment inspection and repair, seeding and sodding, riprap repair, concrete repair, water supply, sewer fee, trash pickup, miscellaneous supplies, building and structure repair, road maintenance, and pump station operation.

TABLE D-3
STE. GENEVIEVE PLAN
SELECTED PLAN
NON-FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
01	LANDS AND DAMAGES				($940,000)
	MAJOR LEVEE AND ASSOCIATED FEATURES				
	Levee:				
	Cropland	114	Acre	1,100.00	$125,400
	Cropland	53	Acre	1,400.00	74,200
	Channel Relocation:				
	Cropland	2	Acre	1,400.00	2,800
	Interior Drainage:				
	Cropland	32	Acre	1,100.00	35,200
	Cropland	9	Acre	1,400.00	12,600
	Borrow:				
	Cropland	54	Acre	1,100.00	59,400
	Cropland	25	Acre	1,400.00	35,000
	Easement:				
	Industrial-R.R. Crossing	1	Acre	1,000.00	1,000
	Severance Damage (10%)				34,560
	Subtotal				$380,160
	Contingencies 25%				95,840
	Subtotal				476,000
	Acquisition Costs:				
	13 ownerships	13	each	4,500.00	58,500

TABLE D-3
STE. GENEVIEVE
SELECTED PLAN
NON-FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
01	LANDS AND DAMAGES (cont'd.)				
	PL 91-646:				
	13 ownerships	13	each	2,500.00	32,500
	TOTAL ESTIMATED REAL ESTATE COST FOR MAJOR LEVEE				$567,000
	SOUTH GABOURI CREEK				
	Levee:				
	Residential	1	Acres	$2,000.00	$ 2,000
	Rights-of-way:				
	Residential	17	Acre	2,000.00	34,000
	Industrial	2	Acre	1,500.00	3,000
	Between Levee and Creek:				
	Residential	1	Acre	2,000.00	2,000
	Severance Damage (10%)				4,000
	Subtotal				$ 45,000
	Contingencies 25%				11,000
	Subtotal				
	Acquisition Costs 42 ownerships	42	each	4,500.00	189,000
	TOTAL ESTIMATED REAL ESTATE COST FOR SOUTH GABOURI				$245,000

TABLE D-3
STE. GENEVIEVE
SELECTED PLAN
NON-FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
01	LANDS AND DAMAGES (cont'd.)				
	NORTH GABOURI CREEK				
	Levee:				
	Recreational	1	Acre	$3,000.00	$ 3,000
	Rights-of-way:				
	Residential	8	Acre	2,000.00	16,000
	Commerical	1	Acre	5,000.00	5,000
	Between Levee and Creek:				
	Recreational	2	Acre	3,000.00	6,000
	Improvements				20,000
	Severance (10%)				5,000
	Subtotal				$ 55,000
	Contingencies 25%				14,000
	Subtotal				69,000
	Acquisition Costs 12 ownerhsip	12	each	4,500.00	54,000
	PL 91-646 1 ownership	1	each	5,000.00	5,000
	TOTAL ESTIMATED REAL ESTATE COST FOR NORTH GABOURI				$128,000
	TOTAL LANDS AND DAMAGES				$940,000

TABLE D-3
STE. GENEVIEVE
SELECTED PLAN
NON-FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
02	RELOCATIONS				($1,190,000)
	MAJOR LEVEE AND ASSOCIATED FEATURES				
	Citizen Electric Corp. Power Lines:				
	2.4/4.16 KV Line	2	Ea	$15,000.00	$30,000
	7.2 KV Line	1	Ea	15,000.00	15,000
	34.5 KV Line	1	Ea	25,000.00	25,000
	Subtotal				70,000
	Contingencies				20,000
	TOTAL RELOCATIONS FOR MAJOR LEVEE				$90,000
	SOUTH GABOURI CREEK				
	Citizens Electric Corp:				
	2.4/4.16 KV Line	.50	Mile	36,800.00	$ 18,400
	34.5 KV Line	.11	Mile	230,000.00	25,300
	Southwestern Bell Co:				
	Overhead Line	.25	Mile	15,000.00	3,750
	Buried Cable	.10	Mile	20,000.00	2,000
	Bridges:				
	7th Street Bridge	1	Each	100,000.00	100,000
	8th Street Bridge	1	Each	100,000.00	100,000
	9th Street Bridge	1	Each	100,000.00	100,000

TABLE D-3
STE. GENEVIEVE
SELECTED PLAN
NON-FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
02 RELOCATIONS (cont'd)					
SOUTH GABOURI CREEK (cont'd)					
	10th Street Bridge	1	Each	100,000.00	100,000
	Degrade Bridges	3	Each	5,000.00	15,000
	Wing Walls to 4th and 6th Street Bridges	2	Each	15,000.00	30,000
	Subtotal				$494,450
	Contingencies				133,550
	TOTAL RELOCATIONS FOR SOUTH GABOURI				$628,000
NORTH GABOURI CREEK					
	Citizens Electric Corp:				
	2.4/4.16 KV Line	.40	Mile	$ 36,800.00	$ 14,720
	Southwestern Bell Co:				
	Overhead Line	.60	Mile	15,000.00	9,000
	Sewer Service:				
	Remove Old Sewer	1,300	L.F.	2.50	3,250
	Remove Manhole	5	Each	150.00	750
	Excavation	8,100	C.Y.	2.00	16,200
	New Pipe	1,600	L.F.	8.00	12,800
	New Manholes	7	Each	900.00	6,300
	Backfill	8,100	C.Y.	1.50	12,150

TABLE D-3
STE. GENEVIEVE
SELECTED PLAN
NON-FEDERAL COSTS

Cost Acct. No.	Description	Quantity	Unit	Unit Price	Total Estimated Cost
02	RELOCATIONS (cont'd)				
	NORTH GABOURI CREEK (cont'd)				
	Bridges:				
	Main Street Bridge	1	Each	150,000.00	150,000
	Fourth Street Bridge	1	Each	150,000.00	150,000
	Subtotal				$ 375,170
	Contingencies				96,830
	TOTAL RELOCATIONS FOR NORTH GABOURI				$ 472,000
	TOTAL RELOCATIONS				$1,190,000
14	RECREATION Note: See Recreation under Federal Cost				($60,000)
30	ENGINEERING AND DESIGN				($150,000)
31	SUPERVISION AND ADMINISTRATION				($60,000)
	TOTAL NON-FEDERAL COST FOR SELECTED PLAN				$2,400,000
	TOTAL CONSTRUCTION COST FOR SELECTED PLAN				$31,500,000

TABLE D-4

ANNUAL OPERATION AND MAINTENANCE COST

OCTOBER 1982 PRICE LEVEL

Item	PLAN NO. 1	PLAN NO. 2	PLAN NO. 3	PLAN NO. 4
Gravity Drainage Structures	$ 1,350	$ 1,060	$ 1,060	$ 0
Pump Station	47,100	54,300	48,800	0
Levee	16,150	18,240	23,740	0
Closure Structures	800	800	800	0
Miscellaneous	-0-	-0-	-0-	3,000
Bridges	1,600	1,600	1,600	-0
Recreation	7,000	7,000	7,000	-0
TOTAL O&M COSTS	$74,000	$ 83,000	$ 83,000	$ 3,000

NOTE: These annual estimated costs are entirely a non-Federal responsibility.

SECTION 6 - RIGHTS-OF-WAY

Approximate permanent rights-of-way required for the selected plan of improvements are as follows:

Lands for Levee	169 acres
Lands for Borrow	79 acres
Lands for Channel Relocation	3 acres
Lands for Interior Drainage	43 acres
Lands for Right-of-way	30 acres
Total Lands Required	324 acres

SECTION 7 - MAJOR REPLACEMENTS

Major replacements of project features are required to insure that project objectives are functional for the duration of the 100-year estimated project life. These major replacement requirements are assumed to occur at varying intervals. The costs of the major replacements are shown in TABLE D-5 based on 7-7/8 percent interest and October 1982 price levels. These costs are in addition to the operation and maintenance costs previously discussed. The local sponsor is required to accomplish all major replacements as they become necessary to insure that the project will meet its objectives for the assumed life of the project.

TABLE D-5

MAJOR REPLACEMENT COSTS

OCTOBER 1982 PRICE LEVEL

Item	PLAN NO. 1	PLAN NO. 2	PLAN NO. 3	PLAN NO. 4
Bridges	$700,000	$700,000	$700,000	$ 0
Closure Structures	455,000	490,000	470,000	0
Recreation	60,000	60,000	60,000	0
Floodwalls	0	0	0	180,000
Pumping Station	1,100,000	1,250,000	1,100,000	0
Gravity Drains	625,000	660,000	530,000	0
TOTAL	$2,940,000	$3,160,000	$2,860,000	$180,000

SECTION 8 - TOTAL ANNUAL REPLACEMENT COSTS

The total annual replacement cost for all plans are shown in TABLE D-6.

TABLE D-6

TOTAL ANNUAL REPLACEMENT COSTS

PLAN NO. 1	PLAN NO. 2	PLAN NO. 3	PLAN NO. 4
$5,000	$6,000	$5,000	$ 300

SECTION 9 - TOTAL ANNUAL PROJECT COSTS

The total annual project costs for the described four plans are shown in TABLE D-7.

TABLE D-7

TOTAL ANNUAL PROJECT COSTS

BASED ON 7-7/8 PERCENT INTEREST AND OCTOBER 1982 PRICE LEVEL

	PLAN NO. 1	PLAN NO. 2	PLAN NO. 3	PLAN NO. 4
CONSTRUCTION FIRST COST	$31,500,000	$33,000,000	$31,700,000	$ 410,000
ANNUAL FIRST COST EQUIVALENT	2,955,000	3,098,000	2,978,000	32,000
ANNUAL O&M COST	74,000	83,000	83,000	3,000
ANNUAL MAJOR REPLACEMENT	5,000	6,000	5,000	300
TOTAL ANNUAL PROJECT COST	$ 3,034,000	$ 3,187,000	$ 3,066,000	$ 35,000

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

APPENDIX E

CULTURAL RESOURCES

STE. GENEVIEVE, MISSOURI

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CULTURAL RESOURCES

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APPENDIX E

CULTURAL RESOURCES

SECTION 1 - EXISTING CONDITIONS OF CULTURAL RESOURCES

1.1 HISTORICAL RESOURCES

Ste. Genevieve is the oldest permanent European community in Missouri, first settled over 200 years ago by French colonists. Although some (not necessarily incorrect) estimates place the founding of Ste. Genevieve at 1723, the earliest firm documentation of the settlement is a 1752 census which includes Ste. Genevieve. Today, the town can rightly boast a significant documentary record, and its surviving French colonial architecture is unequalled in the United States, facts which have led scholars from the University of Missouri to believe that Ste. Genevieve "is the single best community for detailed analysis of the French experience in the middle Mississippi Valley."

After its founding near or before the middle of the 18th century, Ste. Genevieve underwent development as a regional trading center, an agricultural community, and a port from which lead and salt were shipped. Many early inhabitants of Ste. Genevieve operated small-scale lead mining claims at the headwaters of Big River. The town was originally built southeast of its present location, and nearer to the

river in the Big Field or "Le Grand Champ". Then in the 1700's a number of river floods occurred, culminating in 1785, "l'anee des grandes eaux", a flood season so severe that it prompted Ste. Genevievians to begin relocating the town to its present site. Still to be seen in Ste. Genevieve and dating from the 18th century are the architectural legacies of France, Quebec, Lower Louisiana, and the West Indies. A good example is the Pierre Bolduc House (FIGURE 1), where one can view the 18th century French Norman Truss, the poteaux-en-terre walls of upright posts set in the ground, which orginated either in Lower Louisiana or the Caribbean, and the combination of a steep hipped roof (Quebec) and the galerie - the wrap-around porch with low hipped roof. Also unique to Ste. Genevieve was the comparatively long persistence of common field agriculture, a practice in which individual holdings were divided into "arpents", long narrow lots 192 to 200 feet wide running perpendicular to the river. Pecan trees growing on the floodplain east of town still mark some of the arpent lines.

Anglo-American immigration to Ste. Genevieve began about 1796, and a significant German immigration began about 1830. The result has been a diversity of standing architecture, including nearly 50 French colonial buildings, of which 35 were built before 1803, as well as many examples of Anglo-American and German architecture. Ste. Genevieve's significant historical and architectural heritage has won national recognition. Part of the community is a registered National Historic Landmark, and is listed on the National Register of Historic Places.

FIGURE 1

The Pierre Bolduc House, built before 1785 and moved to its present location after the Great Flood of 1785. It was completely restored during the 1950's.

The National Landmark inventory originally included 79 historic buildings. This list is presently being updated by scholars from the University of Missouri, and as of February 1983 it had been expanded to a list of 154 buildings, of which 121 are within the St. Louis District's floodplain inventory and of which 87 are actually subject to flooding. PLATE 3 shows the locations of the 154 historic buildings in the current University of Missouri inventory. The list is still being expanded, and will ultimately include representatives of all periods of architecture and history at Ste. Genevieve.

Although Ste. Genevieve is known primarily for its early French colonial settlement (1750-1825) and architecture, its historical buildings also represent German and American immigration during the 19th century and later. In the St. Louis District's floodplain inventory of Ste. Genevieve, 23 buildings date from the 1700's; 183 from the 1800's; and 189 from this century; nearly 50 buildings are of French colonial design; and 12 exhibit German architecture.

1.1.1 Significance.

As mentioned, a large portion of the community of Ste. Genevieve is listed as the Ste. Genevieve National Historic Landmark, by virtue of which designation it is also included in the National Register of Historic Places (National Register). The National Register is the nation's official list of properties worthy of preservation for

significance in American history, architecture, archaeology, and culture. Because the town has this distinction, it has a special status in the process of planning any federal undertaking which may affect the National Register District.

With its French heritage and the continuity of its subsequent settlement and occupation, Ste. Genevieve is a place unique on the Mississippi River and in the United States as a whole. Some feeling of this dimension of the town's significance was provided by Barbara Bacot, architectural historian at the Louisiana Historic Preservation Office (interview, 9 September 1982), who stated that only two 18th-century French structures remain on the Mississippi River in Louisiana and that even the city of New Orleans falls short of having Ste. Genevieve's number of 18th-century French residences. Ms. Bacot also stated that the survival of the Ste. Genevieve settlement is unique on the river and that it has the greatest concentration anywhere in the United States of 18th-century French residences. She noted that architectural historians travel from Louisiana to Ste. Genevieve to study 18th-century architecture.

Nationally recognized historians, architects, and local residents alike are all enthusiastic about Ste. Genevieve's heritage and its potential for further study. Vast historical documentation, much of it handwritten in French, has just begun to be tapped, and the knowledge and documentation gathered by Ste. Genevieve's citizens hold great promise for scholars of history and architecture. The town's long occupation, its architectural survival, and its historical archives together contribute to an extensive and detailed historical record potentially

surpassing that of the more thoroughly studied eastern seaboard colonies. The architectural and historic significance of Ste. Genevieve cannot be overstated.

1.2 ARCHAEOLOGICAL RESOURCES

Prehistoric use of the Ste. Genevieve vicinity was significant. The Saline Creek, southeast of Ste. Genevieve, was used as a hunting ground at least as early as the Archaic Period (7000 BC to 1000 BC). Beginning during the Woodland Period (1000 BC to AD 900) people engaged in salt making at the salt springs, and this practice continued through the Mississippian Period (AD 900 to AD 1700). The technology of salt production involved the use of large ceramic salt "pans" on which salt was precipitated by evaporating the brackish water obtained from the springs. This technology remained unchanged throughout the Woodland and Mississippian periods, and in fact was also practiced by the early French settlers, the only difference being that the French used iron kettles. Archaeological remnants of Woodland, Mississippian, and French colonial salt production abound on the Saline (FIGURE 2a).

Closer to Ste. Genevieve, the Common Fields Archaeological Site just southeast of town was a fortified Mississippian mound and village complex dating to about AD 1300 to 1400. Another Mississippian village site (the Bauman site, discussed in more detail below) was discovered in 1983 and is even closer to downtown Ste. Genevieve. Mississippian artifacts have also been unearthed within the Ste. Genevieve city limits.

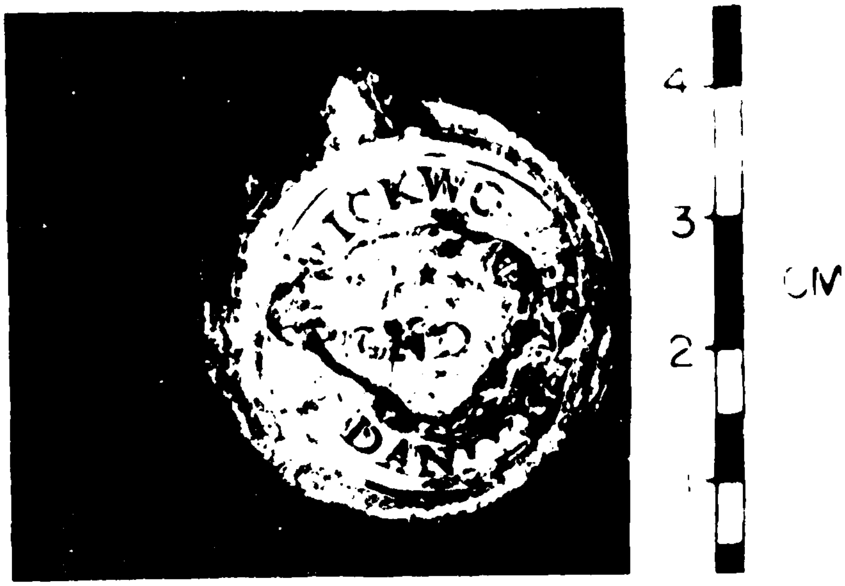
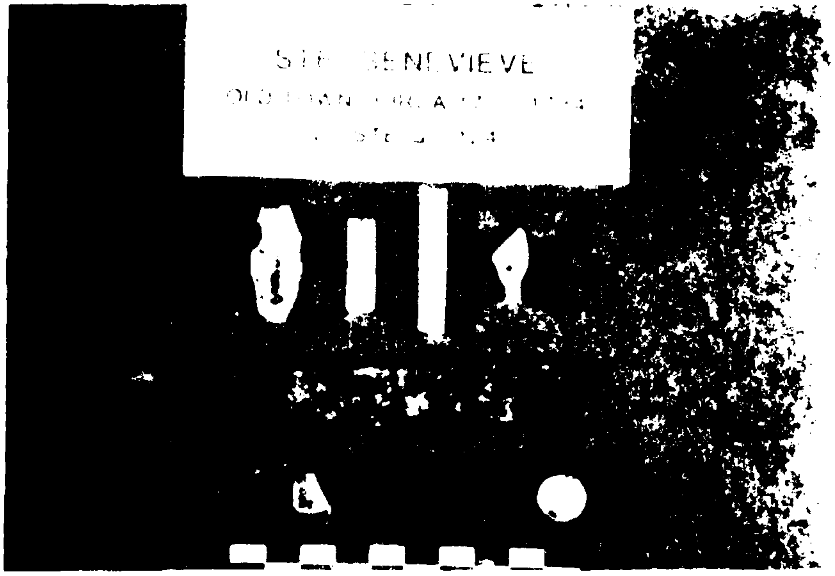


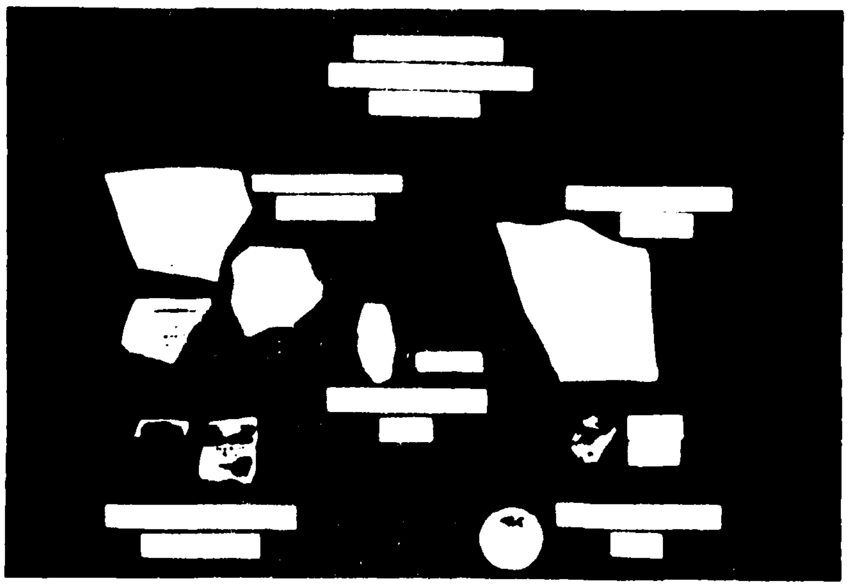
FIGURE 2a

Baling seal dating from French colonial use of the Saline Creek.

FIGURE 2b

Silver de[illegible] [illegible]ected from the [illegible] Town Ste. Genevieve site.





FIGURES 2c, 2d

Artifacts collected from Old Town Ste. Genevieve. Subsequent to the time these photos were made, it has become generally assumed that the town was founded between 1748 and 1752, and was moved in 1785.

Also on the Common Fields are found the archaeological remains of the original Ste. Genevieve townsite, discovered by St. Louis District during 1979. Soil stains and artifact concentrations show the locations of ruined structures. Artifacts collected from the site (FIGURES 2b, 2c, 2d) include domestic goods and construction materials, as well as a silver decorative item (possibly part of a cufflink) embossed with the visages of King Louis XV and (possibly) his wife Maria, dating from about 1720 to 1740.

Given the density of prehistoric and early historic occupation on the Common Field and along Saline Creek, the potential for locating yet-undiscovered prehistoric remains is considered good. The possibility is also very good that archeological deposits dating from the historic period exist on the floodplain, especially in areas immediately east of downtown Ste. Genevieve and along St. Mary's road. A preliminary survey, conducted under the auspices of St. Louis District, resulted in the discovery of six historic-period archaeological sites on the floodplain east of town. Dates inferred for the sites range from the early 1800's into the present century. Additional, undiscovered, historic deposits probably exist both on the floodplain and in town.

1.2.1 Significance.

The archaeological sites located in the project area have not been sufficiently well studied to allow determination of their eligibility for the National Register. Such evaluation would be forthcoming in case any Corps undertaking would affect these properties.

In broad terms, prehistoric archaeological sites are likely to be evaluated in light of their relationships to the important sites on Saline Creek and in the Common Field. Historic period archaeological sites are important because they provide information about early town planning, about changes in Ste. Genevieve's settlement pattern, and about historic property attrition. Significance may also derive from the "unwritten" historical information contained in archeological deposits.

SECTION 2 - FUTURE CONDITIONS OF CULTURAL RESOURCES WITHOUT CORPS PROJECT

2.1 HISTORICAL RESOURCES

It has already been stated that 87 of 154 historically significant buildings in Ste. Genevieve are within the Urban Design or Standard Project Flood zone. Floods can cause irreparable damage to structures, and without a Corps flood protection project, these 87 buildings will continue to be susceptible to such damage. Attrition of historic structures due to flooding has been occurring throughout Ste. Genevieve's history, and will continue as long as flood protection is not in place.

Some information pertaining specifically to attrition of French colonial buildings has been obtained from the University of Missouri's community study at Ste. Genevieve. In 1803, there were roughly 150 French colonial buildings in Ste. Genevieve; of these, 35 now remain. Between 6 and 10 buildings were lost in the last decade alone. Not all of the buildings destroyed have been lost directly as a result of flooding, but it is known (for example) that the 1973 flood damaged two French colonial buildings beyond salvage. More than 18 floods of similar magnitude (though lower in stage) have occurred in the last 140 years and must have contributed to the attrition of historic buildings, and similar future floods will, without a Corps project, continue the trend. Given that over three-fourths of Ste. Genevieve's original French colonial buildings have been lost in 180 years, this facet of the town's historical resource must be called endangered.

2.2 ARCHAEOLOGICAL RESOURCES

Archaeological deposits in floodplain soils are particularly prone to disturbance and destruction by flooding. The Common Fields Archaeological Site provides an example. This site was severely damaged by scouring floodwaters during the December 1982 flood. Additional damage has occurred in 1983. Also in 1982, the December flood waters broke an agricultural levee at the Ste. Genevieve sewage lagoons, and the incoming water scoured a long, deep channel into the floodplain. The scour channel has been enlarged by high water during 1983, and is now 3000 feet long, 100 to 150 feet wide, and up to 30 feet deep. St. Louis District inspected the damage in May, 1983, and found that the Bauman site, a previously undiscovered Mississippian archaeological site (FIGURE 3) had been exposed and severely impacted. Ceramics, chipped stone artifacts, ground stone tools, a galena cache, and some historic-period artifacts were recovered and indicate a substantial occupation site of some significance.

Because floodplain sites are lower in elevation than is the town of Ste. Genevieve, these will experience damage even more frequently than will the town itself. In fact, nearly all of the floodplain immediately east of town lies within the five-year frequency flood zone. Undoubtedly, recurrent damage has occurred to archaeological sites there, and will continue without a Corps flood protection project.

FIGURE 3

Erosional damage to the Bauman site, caused by 1982 and 1983 Mississippi River flooding. Some artifacts collected from the site are shown in the foreground.

SECTION 3 - CULTURAL RESOURCE PROBLEMS AND OPPORTUNITES

3.1 FLOODING PROBLEMS

The immediacy of flood damage to historic structures is suggested by the photographs found on the next few pages (FIGURES 4a-4h). The photographs were taken in 1983 and show six historically and architecturally significant buildings which all suffered first floor damage during the Mississippi River flood of May, 1983.

The 1973 Mississippi River flood reached 199 structures which were not protected by emergency sandbag levees. At least 62 additional structures were protected by sandbagging and would have been flooded above the first floor had emergency protection not been provided. The 199 unprotected structures included 40 historic buildings; the 62 protected structures included 17 historic buildings.

More than one-third of Ste. Genevieve's historic buildings are within the 100-year Mississippi River flood zone, and over one-half are within the Urban Design flood zone.

FIGURE 4a

The Michael Placet House, a French Colonial residence built in 1791.

FIGURE 4b

The Michael Placet House during the Mississippi River flood crest, May 5, 1983.

FIGURE 4c

The Christian Luecke building (left) built about 1840 in the German architectural style, and the Wendolia Obermiller building (right) built in the 1840's in the American Frame architectural style.

FIGURE 4d

The same two buildings during the Mississippi River flood crest, May 5, 1983.

FIGURE 4e

Two homes in the High Victorian Italianate architectural style, built about 1870.

FIGURE 4f

The same two homes during the Mississippi River flood crest, May 5, 1983.

FIGURE 4g

A home in the American Frame architectural style, built about 1890.

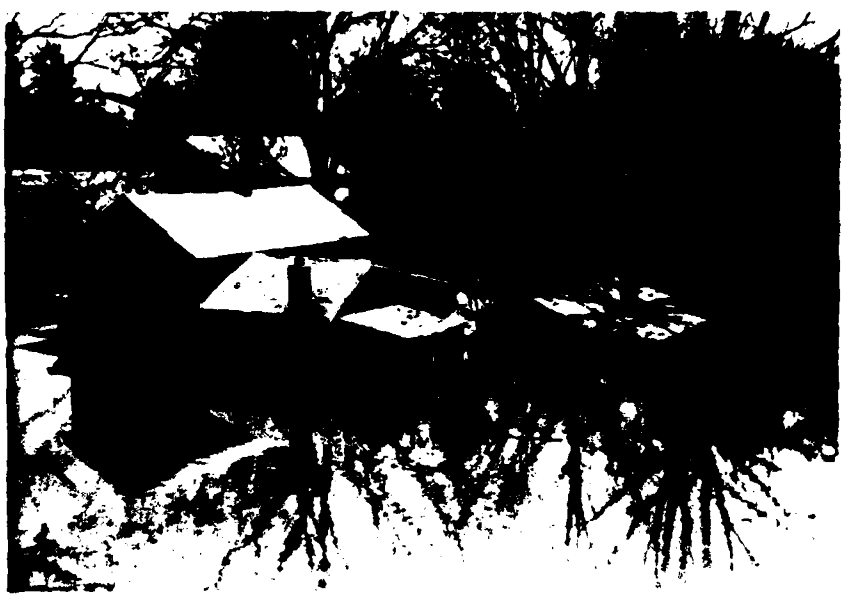


FIGURE 4h

The same home during the Mississippi River flood crest, May 5, 1983.

3.2 HISTORIC STRUCTURE ATTRITION

The attrition of historic structures due to flood damages has been discussed under the "Future Conditions" heading. Flood-caused attrition of historic buildings is a major problem and concern. The most important point is that the enduring historic properties are irreplaceable, in the sense that they are the original historic fabric, not replications. This quality is what perhaps best separates Ste. Genevieve from historic sites like Colonial Williamsburg, where the original buildings had been lost down to the foundations, and where the now-standing historic buildings are either replications or buildings relocated from off-site. Thus, no amount of knowledge or replication of Ste. Genevieve's historical architecture can adequately replace what now exists in the town. By the same token, relocating historic buildings to new, flood free sites would harm Ste. Genevieve's unique historical character. That several French colonial buildings were moved in 1785 from the Old Town to the present site does not in any way diminish this potential impact. The houses were moved by the choice and toil of the early French colonialists, and the present town grew up around them. The entire historic setting depends on their existing placement.

In the discussion already presented, "attrition" was construed as a possible result of a single episode of severe flood damage. It is also obviously the case that a structure may be gradually ruined by repeated floodings through time. An example is the Jean-Paul Robert House, on North Gabouri Creek, where repeated inundations have caused the floor

joists to begin rotting, thereby jeopardizing the interior of the structure. The French colonial poteaux-en-terre structures, with their wood and earth foundations, would appear particularly susceptible to this sort of hazard. Even stone or concrete foundations will succumb to repeated seepage problems.

Some clues regarding structure attrition due to flooding are provided by archaeological survey and by old maps of Ste. Genevieve. Historic archaeological sites on the floodplain east of town have already been discussed. An 1867 map of Ste. Genevieve shows the town extending onto the floodplain east of St. Mary's Road, and all the way to the confluences of North and South Gabouri Creeks. These locations coincide with historic archaeological sites. By the time another map was made in 1880, few buildings were left east of St. Mary's Road or east of Front Street. This is not certain evidence that flooding was the cause for abandonment, but these areas are more flood-prone than are the comparatively higher elevations in town.

There are other dimensions of the problem. A family considering owning and occupying a historic home will obviously be discouraged from making the financial and emotional commitment to a structure if the home is flood-prone. The difficulty of keeping a flood-prone structure in good repair does not only affect its attractiveness on the real estate market, but also, in the long run, has adverse consequences for its historic integrity, even if total loss does not immediately result.

A final problem relates to economic incentives for rehabilitation of historic buildings (to be discussed in the next section). Just as anyone will be discouraged from purchasing and residing in a flood-prone historic home, so will business people be likely to regard purchase, or rehabilitation or restoration, of a flood-prone building a risky business investment. That businesses can be operated in a manner compatible with, in fact beneficial to, a historic property is amply demonstrated in restaurants like the Old Brick House and the Anvil. Neither building has ever been flooded. One wonders, though, what the condition of these structures might be today if they had been susceptible to the flooding Mississippi.

In Ste. Genevieve, a local ordinance strictly prohibits the wanton demolition of historic buildings. Accidents such as fires, and natural disasters such as flooding, are the candidates upon which to blame historic structure attrition. Of these two, flooding affects the largest number of buildings with the greatest frequency.

In describing various flood-related preservation problems, we are attempting to answer those who may doubt that flooding is the "primary cause" of historic structure attrition in Ste. Genevieve. It seems futile to search for the primary cause of historic structure attrition; there are many interacting factors. However, we are suggesting that among these, flooding is the first, primary link in a causal chain that results in structure attrition. The mere fact that a building is floodprone directly affects its property value, has implications for the

owner's financial capability to undertake restoration, can mean frequent interruption of occupancy, can discourage the historically-minded buyer, and so forth. The ultimate fate of a historic building is thus dependent upon a number of factors, listed here and above. But the single factor that sets all the others into motion, the primary causal factor, is flooding.

3.3 HISTORIC PRESERVATION OPPORTUNITIES

From the preceeding discussion of historic structure attrition, it follows that the Corps of Engineers has the opportunity indirectly to stimulate historic preservation by providing flood protection. However, realistically speaking it must be stressed that direct preservation activities must be generated within the community itself. The following discussion, then, is concerned to show what the community may potentially do to preserve and enhance its historical resource, and also to show how these activities depend largely on the stimulus that flood protection would provide.

The first opportunity arises from Economic Recovery Tax Act of 1981 (ERTA). This act provides generous tax incentives for restoration and rehabilitation of income-producing buildings (buildings used at least partially to house a business), only if the building is a "certified" historic property. A "certified" historic property is one that is listed on, or is eligible for listing on, the National Register of Historic Places. It has already been said in this report that 79 structures in

Ste. Genevieve currently enjoy this designation, and that the University of Missouri community study team is working to update and expand the list. The success of ERTA in stimulating historic restoration and rehabilitation is demonstrated by the fact that, as of November 1982, over $290 million had been spent in Missouri under the auspices of ERTA.

Further opportunities follow from the fact that the Federal Government provides incentives for student preservation internships, preservation education, and for the restoration of historic residences, businesses, and neighborhoods. In addition, Ste. Genevieve has the opportunity, through the mechanisms of local ordinances and preservation planning, both to provide for curation of its cultural heritage and to provide a model case of development compatible with indigenous, surviving historical properties.

The most significant opportunity on the horizon for Ste. Genevieve will result from the University of Missouri's community study, which promises to provide an unsurpassed knowledge and understanding of the town's cultural, historical, and architectural heritage. Rather than being specific to the 79 original landmark properties, this study is treating the community as a whole, thereby creating the opportunity for broad-based public education and involvement, for a well-rounded program of historic architectural preservation, and for quality long-range planning. The study team is explicitly concerned first with providing meaningful returns to the local community, and only second with its own scholarly interests.

The Corps of Engineers can not directly cause preservation and enhancement of Ste. Genevieve's cultural resource. However, flood protection would provide an essential stimulus, an important first step.

In Ste. Genevieve, historic buildings provide evidence both for the town's interest in preserving and restoring historic structures, and for the notion that such activities are much less likely to occur at frequently flooded sites that at sites infrequently flooded. FIGURE 5 shows comparisons between buildings that begin to be damaged by the 25-year flood event (FIGURES 5a-5h) and buildings not damaged before the 100-year event (FIGURES 5i-5m). Restoration and rehabilitation have been successfully accomplished at the less frequently flooded buildings; the same is not true of those flooded more frequently. There are exceptions of course, a good example being the Millard House (FIGURE 5f), restored despite its susceptibility to 25-year flooding, but in general it seems to be true that without flood protection, deterioration and attrition of historic buildings will go on.

FIGURE 5a

The Moses Austin House, a French Colonial residence built in 1795. Basement damage begins with the 25-year Mississippi River flood; first floor damage begins with the 50-year Mississippi River flood. No preservation or resotration efforts have been made.

FIGURE 5b

The Charles S. Hertich House, a residence in the Second Empire style, built in 1820. Basement damage begins with the 25-year Mississippi River flood; first floor damage begins with the 50-year Mississippi River flood. Above the first floor, this home has been rehabilitated. No preservation efforts have been made in the basement.

FIGURE 5c

A residence in the German style, built in 1860. Basement damage begins with the 25-year Mississippi River flood; first floor damage begins with the 50-year Mississippi River flood. No preservation or restoration efforts have been made.

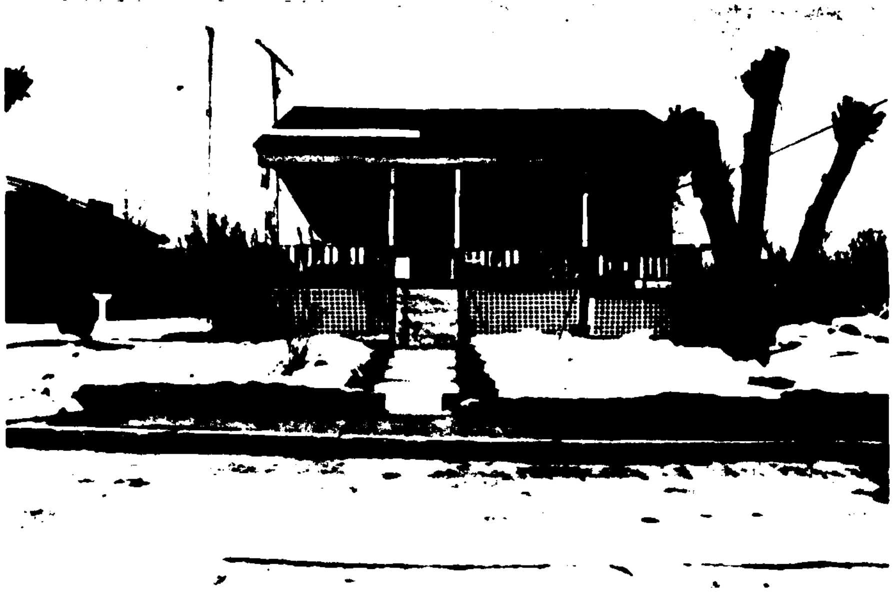


FIGURE 5d

A French Colonial residence built in 1820. Basement damage begins with the 25-year Mississippi River flood; first floor damage begins with the 50-year Mississippi River flood. No preservation or restoration efforts have been made.

FIGURE 5e

The Jean-Baptiste Birke House, a French Colonial residence built about 1795. The house has no basement; first-floor damage begins with the 25-year Mississippi River flood. No preservation or restoration efforts have been made.

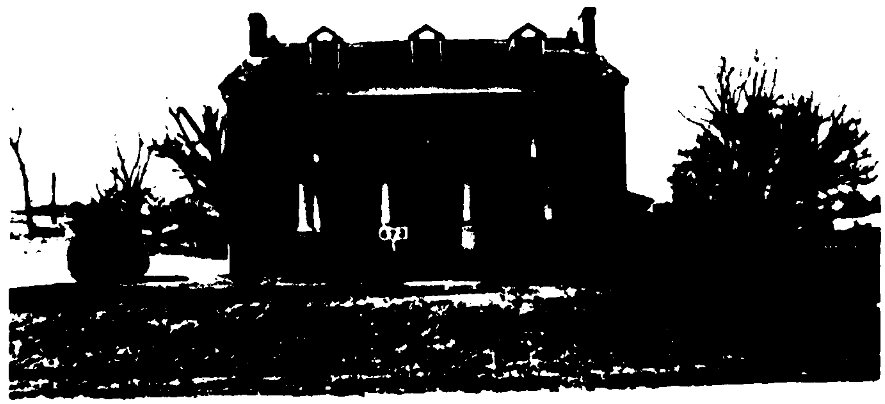


FIGURE 5f

The Josiah Millard House, a stone French Colonial residence built about 1803-1810. Basement damage begins with the 25-year Mississippi River flood; first floor damage begins with the 50-year Mississippi River flood. Rehabilitation of this home is underway. The homeowner protects it during high water with a sandbag levee.

FIGURE 5g

The Bertha Doerge House, built in the German style about 1870. The house has no basement; first-floor damage begins with the 25-year Mississippi River flood. No preservation or restoration efforts have been made.

FIGURE 5h

A house in the American Frame style, built about 1900. The house has no basement; first floor damage begins with the 25-year Mississippi River flood. The white frame structure next door is the Michael Placet home. No preservation or restoration efforts have been made at either building.

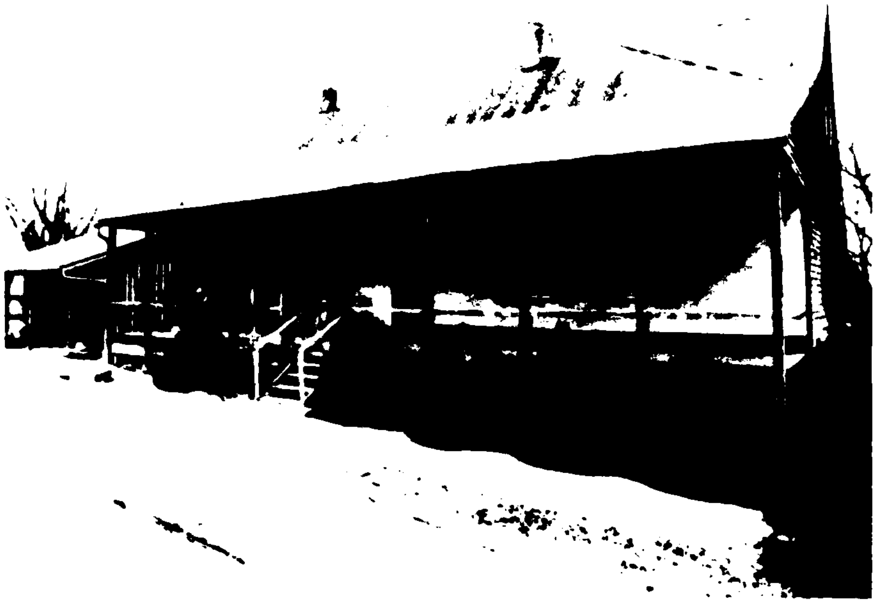


FIGURE 5i

The St. Gemme-Amoreaux House, a French Colonial residence built in 1795. Basement damage begins with the 100-year Mississippi River flood; first floor damage begins with the 500-year Mississippi River flood. This residence has been completely restored. It is open for public tours.

FIGURE 5j

The Bolduc-Lemeilleur House, a French Colonial residence built in 1814. The house has no basement; first floor damage begins with the 500-year Mississippi River flood. This residence has been completely restored. It is open for public tours.

FIGURE 5k

The Pierre Bolduc House, a French Colonial residence built before 1785. Basement damage begins with the 100-year Mississippi River flood; first floor damage begins with the 500-year Mississippi River flood. This residence has been completely restored. It is open for public tours, and is probably the French colonial home most frequently toured by visitors to Ste. Genevieve.

FIGURE 5l

The Green Tree Tavern, originally a French Colonial residence built in 1790. Basement damage begins with the 100-year Mississippi River Flood; first floor damage begins with the 500-year Mississippi River flood. This building has been completely restored and is open for public tours.

FIGURE 5m

The Jean Baptiste Valle House, a French Colonial residence built in 1785. Basement damage begins with the 500-year Mississippi flood; first floor is above the Urban Design Flood Zone. This residence has been completely restored. It is a private home.

3.4 CULTURAL RESOURCE OBJECTIVES

St. Louis District's planning objectives relevant to cultural resources include reduction of Mississippi River and tributary flood damages to historic structures and settings, preservation and enhancement of Ste. Genevieve's historic character, and preservation of archaeological resources. Flood protection, though not by itself sufficient to ensure that these objectives will be met, is certainly necessary and is the primary concern. It follows that flood protection measures themselves ought to be compatible with Ste. Genevieve's historic character.

Because Ste. Genevieve's historical significance derives largely from its historical and architectural continuity and from the fact that its architecture survives in place, an important objective is continued in-place preservation of historic buildings. An adjunct desire, and also related to the town's historical continuity, is that the associations of structures, their spatial interrelationships, also be retained. This would require that historic structures not be moved, but also that they not be isolated in any other manner from surrounding structures and neighborhoods. In rare cases, it may be permissible to relocate non-historic structures (those not included in the updated National Register inventory) even if they are in historic areas.

Another dimension of this same objective is to retain the town's visual association with the common fields area, and to minimize disturbance to archaeological sites there.

It is very important that elements out-of-character with Ste. Genevieve's historical setting not be introduced in historic neighborhoods, including and especially the downtown area. Were any flood protection measure to protect floodplain areas east of town, it would be desirable to discourage out-of-character development in those areas, as well.

If flood protection is in fact implemented, assurances should be sought to cause fulfillment of the preservation objectives just discussed. Assurance could take the form of local ordinances or of review and approval by the Missouri State Historic Preservation Office, whenever any land modification, structure modification, or new construction were proposed within the limits of the National Register historic district protected from flooding. The strongest program would be a combination of local ordinance and the city's agreement to consult the SHPO during planning of local projects within the historic district so protected.

SECTION 4 - EFFECTS OF MEASURES ON CULTURAL RESOURCES

4.1 METHODOLOGY FOR EFFECT ASSESSMENT

The extent to which the decision reached in the Ste. Genevieve Feasibility Study must depart from decisions traditionally made using economic BCR's cannot be overstated. The BERH has called the "net benefits" rule into play on their belief that it " . . . provides the basis for recommending projects which have an economic benefit-cost ratio of less than unity, but have an environmental and/or cultural purpose of substantial significance that cannot be evaluated in economic or non-economic terms." Flood protection at Ste. Genevieve has "a cultural purpose of substantial significance." This reasoning follows from the town's National Register significance and from the fact that a decision to take no action constitutes neglect that may result in the deterioration or destruction of the National Register property; a "no action" decision is thus an adverse effect on the property (36 CFR 800.9(e)).

4.1.1 Advisory Council for Historic Preservation Compliance Process.

Procedures for the protection of properties listed on, or eligible for listing on the National Register have been written by the Advisory Council for Historic Preservation (Advisory Council) under the authority of PL 89-665, 80 Stat. 915 (16 U.S.C. 470), and EO 11593. The procedures are regulations aimed at resolving conflicts between purely preservation

interests and purely project interests, with regard to potential effects upon National Register properties, and are intended to reach solutions that best reflect public interests, which will vary between preservation interests and project interests depending upon the particular nature of a given undertaking. Advisory Council regulations are published in the Code of Federal Regulations, Title 36, Chapter VIII (36 CFR 800). They require maximum coordination with the review process established by NEPA, and the Draft Environmental Statement often begins the historic preservation compliance process.

Because the Ste. Genevieve Flood Control Study constitutes a federal undertaking, and because the town is listed on the National Register, consideration of the preservation interest must proceed according to the Advisory Council regulations. In this particular case, the preservation interest and the project interest (i.e., flood protection) are both important in the public eye. A conflict of these interests will arise if flood control is planned at the expense of historic preservation, or if historic preservation is favored at the expense of flood protection. As will be shown, conflicts do arise with some of the protection measures under study. However, eight measures accomplish flood protection and are compatible with historic preservation interests.

The Advisory Council compliance process begins with identification of the cultural resource. This step has been accomplished by virtue of the definition of the Ste. Genevieve National Register district and its boundaries, of the historic structures inventory conducted by the

St. Louis District, and of the historic structures inventory made by the University of Missouri under the auspices of the National Endowment for the Humanities.

The second step in the compliance process is the determination of the undertaking's effect upon the National Register property (36 CFR 800.2, 800.4(b), and 800.8). Effects are relative to the characteristics which qualify the property for listing on the National Register, and may be beneficial or adverse, but not both at the same time. Consideration must be given both to direct effects (those that occur at the same time and place as the undertaking), and to indirect effects that are removed in time or distance. It is the purpose of this appendix to identify effects of eleven levee measures, three nonstructural measures, two channel widening measures, two clearing and snagging measures, and a "no-action" alternative.

If an effect is identified, it must be determined whether the effect will be adverse; this is the third step in the Advisory Council compliance process. Adverse effects, like effects in general, are relative to the characteristics which determine Ste. Genevieve's National Register significance (36 CFR 800.10), and are defined precisely by a set of criteria given in the Advisory Council regulations (36 CFR 800.9). These criteria are listed later in this appendix and are used to determine potential adverse effects of all protection measures and the no-action alternative.

If an adverse effect is identified for any measure, and if it should be the case that implementation of such a measure or alternative will be recommended, consultation with the Advisory Council must occur (36 CFR 800.5) with the objective being to resolve any conflict between the proposed project interest and the preservation interest. A successful consultation results in an agreement that best serves the public interest, which, as has already been expressed, must in this case be anticipated to favor both flood protection and historic preservation.

Preferred alternatives to adverse effect that might be recommended by the Advisory Council in such a case include, but are not limited to, avoidance of adverse effect through project design modification or, where feasible, no action (36 CFR 800.5(c)), and mitigation of adverse effect through design modification or through scientific research designed to salvage information (36 CFR 800.5(f)). It will generally be beyond the scope of this appendix to request such recommendations for specific measures or alternatives. However, it should be realized that because the Study will consider 18 protection measures and a no-action alternative, the St. Louis District has the opportunity to screen for the measure or alternative which best represents agreement between the historic preservation and project interest and, hence, the public interest.

Previous correspondence between the U.S. Army Corps of Engineers, the National Park Service, and the Ste. Genevieve Restoration Commission has highlighted the difficulty of assigning monetary or economic measures

to Ste. Genevieve's historical values (Letters: Missouri SHPO to NPS, 30 January 1975; NPS to SHPO, 25 February 1975; Ste. Genevieve Restoration Commission to NPS, 8 January 1975; NPS reply, February 1975; NPS to SLD, 1 May 1975; see APPENDIX H). For the reason that no satisfactory method of this kind exists, we will represent cultural benefits and costs by levels of impact upon the town's historical qualities of National Register significance.

4.1.2 Adverse Effect.

The federal regulations regarding protection of National Register properties are quite explicit on the matter of adverse effect. They state (36 CFR 63) that adverse effects include, but are not limited to;

(1) Destruction or alteration of all or part of a property;

(2) Isolation from or alteration of the property's surrounding environment;

(3) Introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting;

(4) Neglect of a property resulting in its deterioration or destruction.

The term "property" in this case refers to the Ste. Genevieve historic district, as an entirety and as its individual components (i.e., the University of Missouri's inventory of 154 historic buildings).

4.2 FIRST ITERATION

Effects have been identified for all of the levee measures and for both demolition/relocation measures, and overall adverse effects have been identified for all but Measures 6 and 8. The totals represented in TABLE 8 represent in each case the severity of adverse effect that would accrue from implementation, or perhaps more properly, represent the divergence between preservation and project interests in each case. The large negative numbers show extreme divergence or conflict of preservation and project interests, which divergence decreases as negative numbers get smaller. Just as BERH has stated, ". . . economic costs and benefits may not be the only factor in determining feasibility . . ." From the viewpoint which gives flood protection at Ste. Genevieve its purpose, no alternative among Measures 1 through 5, 7, 20, and 21 is singly feasible; no alternative being a combination of any two or more measures among Measures 1 through 5, 7, 20, and 21 is feasible; nor is a "no action" alternative feasible.

Only Measures 6 and 8 are feasible. Measures 6 and 8 represent beneficial effects to the historic resources, and relative agreement between preservation and project interests.

4.2.1 No Action Alternative.

Given Ste. Genevieve's susceptibility to flooding, and given that significant historical structures are within the 1973 flood zone (TABLES E-1, E-2), 100-year flood zone (TABLES E-4 and E-5), and Urban Design flood zone (TABLES E-6 and E-7), a decision to take no action will indirectly affect the National Register District's historic quality. To take no action would be an adverse effect, in that it would constitute "neglect of a property resulting in its deterioration or destruction" (36 CFR 800.3(b)(4)). Consequently, the no action alternative is seen as adverse to both the preservation and the project interests.

TABLE E-1

Ste. Genevieve, Missouri
Structures Flooded by 1973 Flood[1/]

	Historic Buildings[2/]	Other Buildings	Total
South of S Gabouri			
Below 1st floor	5	9	14
Above 1st floor	2	15	17
Total	(7)	(24)	(31)
Between N&S Gabouri			
Below 1st floor	4	6	10
Above 1st floor	10	71	81
Total	(14)	(77)	(91)
North of N Gabouri			
Below 1st floor	15	17	32
Above 1st floor	4	41	45
Total	(19)	(58)	(77)
Totals			
Below 1st floor	24	32	56
Above 1st floor	16	127	143
Total	(40)	(159)	(199)

1/ Excludes at least 62 (including 17 historic) structures protected by sandbag levees in 1973.

2/ "Historic Buildings" are included among those which the University of Missouri community study will add to the Ste. Genevieve National Register District, as of June 1983.

TABLE E-2

Structures with Water in First Floor
1973 Flood[1]

Historic Buildings[2]	Others					
48	44	121	267	324	514	771
76	45	122	268	325	516	823
77	47	123	269	326	518	824
86	78	125	270	327	704	825
115	79	126	271	328	705	826
261	81	157	272	329	706	827
316	83	158	273	330	707	828
322	84	161	274	332	708	829
323	85	162	279	333	709	836
506	87	258	280	334	710	838
734	88	259	282	336	711	840
739	89	260	286	337	713	846
740	116	262	287	338	714	848
743	117	263	288	339	728	852
745	118	264	289	340	744	855
837	119	265	307	342	746	
	120	266	308	474	747	
			309	482	748	
			310	502	749	
			311	503	761	
			313	507	763	
			314	509	764	
			315	510	765	
			318	511	766	
			319	512	770	
			320	513		
			321			

1/ Additional buildings, not listed, received basement damage only.

2/ As defined in TABLE E-1, note 2.

TABLE E-3

Structures Protected by Sandbags in 1973

Historic Buildings[1]	Others		
21	9	124	702
105	10	128	727
106	11	164	728
111	12	275	730
112	13	296	732
163	14	298	758
506	15	300	759
725	16	301	760
726	17	303	767
729	18	304	772
733	20	312	773
736	50	407	833
737	51	409	834
738	107	416	835
741	108		839
742			842
841			

1/ As defined in TABLE E-1, note 2.

TABLE E-4

Ste. Genevieve, Missouri
Prediction for 100-Year Flood - Historic Structures1/

	Mississippi River	North Gabouri	South Gabouri
South of S Gabouri			
Below 1st floor	6	N/A	1
Above 1st floor	2	N/A	3
Total	(8)	(N/A)	(4)
Between N&S Gabouri			
Below 1st floor	14	2	3
Above 1st floor	28	0	7
Total	(42)	(2)	(10)
North of N Gabouri			
Below 1st floor	2	2	N/A
Above 1st floor	12	4	N/A
Total	(14)	(6)	(N/A)
Totals			
Below 1st floor	22	4	4
Above 1st floor	42	4	10
Total	(64)	(8)	(14)

1/ As defined in TABLE E-1, note 2.

TABLE E-5

Ste. Genevieve, Missouri
Prediction for 100-Year Flood - Entire Community

	Mississippi River	North Gabouri	South Gabouri
South of S Gabouri			
Below 1st floor	24	N/A	3
Above 1st floor	47	N/A	10
Total	(71)	(N/A)	(13)
Between N&S Gabouri			
Below 1st floor	30	13	14
Above 1st floor	137	24	16
Total	(167)	(37)	(30)
North of N Gabouri			
Below 1st floor	19	27	N/A
Above 1st floor	131	34	N/A
Total	(150)	(61)	(N/A)
Totals			
Below 1st floor	73	40	17
Above 1st floor	315	58	26
Total	(388)	(98)	(43)

TABLE E-6

Ste. Genevieve, Missouri
Prediction for UDF AND SPF - Historic Structures[1/]

	Mississippi River	North Gabouri	South Gabouri
South of S Gabouri			
Below 1st floor	0	N/A	0
Above 1st floor	9	N/A	4
Total	(9)	(N/A)	(4)
Between N&S Gabouri			
Below 1st floor	9	4	3
Above 1st floor	52	18	12
Total	(61)	(22)	(15)
North of N Gabouri			
Below 1st floor	2	4	N/A
Above 1st floor	14	8	N/A
Total	(16)	(12)	(N/A)
Totals			
Below 1st floor	11	8	3
Above 1st floor	75	26	16
Total	(86)[2/]	(34)	(19)

1/ As defined in TABLE E-1, note 2.

2/ The total number of flood prone structures is 87. Of these, one is within the South Gabouri SPF zone but no other flood zones; the other 52 structures within the SPF zone for creeks are also among the 86 structures within the Mississippi River UDF zone.

TABLE E-7

Ste. Genevieve, Missouri
Prediction for UDF AND SPF - Entire Community

	Mississippi River	North Gabouri	South Gabouri
South of S Gabouri			
Below 1st floor	2	N/A	2
Above 1st floor	69	N/A	17
Total	(71)	(N/A)	(19)
Between N&S Gabouri			
Below 1st floor	32	9	18
Above 1st floor	188	83	46
Total	(220)	(92)	(64)
North of N Gabouri			
Below 1st floor	32	24	N/A
Above 1st floor	159	93	N/A
Total	(191)	(117)	(N/A)
Totals			
Below 1st floor	66	33	20
Above 1st floor	416	176	63
Total	(482)	(209)	(83)

TABLE E-8

Cultural Resource Effect Types for First and Second Iteration Measures[1]

First Iteration

	Level of Protection	Type of Effect		Level of Protection	Type of Effect
Measure 1 Levee[2]	30 year	Type 2	Measure 7 Levee/ Floodwall	30 year	Type 1
	100 year	Type 2		100 year	Type 2
	500 year	Type 2		500 year	Type 2
Measure 2 Levee/ Floodwall	30 year	Type 2	Measure 8 Levee	30 year	Type 1
	100 year	Type 2		100 year	Type 1
	500 year	Type 2		500 year	Type 1
Measure 3 Levee/ Floodwall	30 year	Type 2	Measure 15 Recreation	N.A.	N.A.
	100 year	Type 2			
	500 year	Type 2			
Measure 4 Levee/ Floodwall	30 year	Type 2	Measure 20 Relocate 10 Structures Demolish 23 Structures	None[3]	Type 3
	100 year	Type 2			
	500 year	Type 2			
Measure 5 Levee/ Floodwall	30 year	Type 1	Measure 21 Relocate 16 Structures	None	Type 3
	100 year	Type 2			
	500 year	Type 2			
Measure 6 Levee	30 year	Type 1	No Action	None	Type 3
	100 year	Type 1			
	500 year	Type 1			

1/ Type 1 = overall beneficial effect, where measure accomplishes flood protection in a manner compatible with cultural resource preservation; Type 2 = overall adverse effect where measures accomplish some flood protection but directly cause adverse effect to cultural resource; Type 3 = measures which directly cause adverse effects to some historic buildings and/or leave some buildings susceptible to high-frequency floods.

2/ All levee measures were designed for soil fill. Measures 5 through 8 were designed for both soil and hydraulic fill. Cultural resource effects are the same, regardless of fill material.

3/ Measures 20 and 21 provide flood protection only to the relocated structures.

TABLE E-8 (Cont'd)

Cultural Resource Effect Types for First and Second Iteration Measures[1/]

<u>Second Iteration</u>

	Level of Protection	Type of Effect		Level of Protection	Type of Effect
Measure 9 Levee Mississippi	500 year	Type 1	Measure 16 Recreation on Tribs.	N.A.	N.A.
Measure 10 Levee Mississippi	500 year	Type 1	Measure 18 Clear & Snag S. Gabouri	N.A.	Type 3
Measure 11 Levee Mississippi	500 year	Type 1	Measure 19 Clear & Snag N. Gabouri	N.A.	Type 3
Measure 12 Chan/Levee S. Gabouri	25 year	Type 1	Measure 22 Nonstructural N. & S. Gabouri	25 year	Type 1
Measure 13 Chan/Levee N. Gabouri	25 year	Type 1			

1/ Type 1 = overall beneficial effect, where measure accomplishes flood protection in a manner compatible with cultural resource preservation; Type 2 = overall adverse effect where measures accomplish some flood protection but directly cause adverse effect to cultural resource; Type 3 = measures which directly cause adverse effects to some historic buildings and/or leave some buildings susceptible to high-frequency floods.

4.2.2 Measure 1.

By itself, Measure 1 provides flood protection to only a small portion of the entire community. Its beneficial effect is therefore minor. Relocation of three French colonial residences constitutes alteration of part of the National Register property and is thus an adverse effect. Placement of the levee close to St. Mary's Road isolates such structures as the Amoreaux, Bequette-Ribeau, and Elliot houses, and the Green Tree Tavern, from their surroundings, especially the common field area. It also isolates the Vital St. Gemme house from the remainder of town. These also constitute adverse effects.

4.2.3 Measure 2.

By itself, Measure 2 provides at best only moderate flood protection, hence, beneficial effect, relative to the entire community. The fact that it isolates the central portion of town is by definition an adverse effect. That it would introduce visual elements that are out of character with the historic district's integrity also constitutes an adverse effect. Measure 2 would have a further adverse effect in that it would, even in combination with Measure 1, neglect the Valle house, and the Burtcher house, by leaving them outside the Levee along south Gabouri Creek.

4.2.4 Measure 3.

By itself, Measure 3 provides only minor to moderate flood protection benefits. Its adverse effects to the historical significance of Ste. Genevieve would be extreme. The measure would isolate the northern portion of Ste. Genevieve from the remainder of town and from its surrounding environment, an adverse effect as defined. It would result in destruction of part of the National Register property, specifically the 19th-century structure 322, and would alter part of the property by relocation of three French colonial residences (structures 284, 323, and 466). By definition, these are adverse effects.

4.2.5 Measure 4.

Measure 4 offers protection similar to, but slightly less than, that of Measure 2 and its beneficial effects are thus the same. It directly impacts a larger number of structures than does Measure 2, but its adverse effects arise mainly from the facts that it would introduce out-of-character visual elements, actually a more severe impact than for Measure 2, and that it neglects the Valle and Burtcher houses.

4.2.6 Measures 5 and 7.

Measures 5 and 7 would offer flood protection providing moderate to major beneficial effects. Their visual effects on the community would

vary with the design height, but would in general be a minor adverse effect. Either measure would isolate three French colonial residences (structures 75, 76, and 77) from the center of town, and its 100-year and UDF flood walls would be an out-of-character intrusion into the central area of town. By definition, these are adverse effects.

4.2.7 Measures 6 and 8.

These measures provide flood protection to nearly the entire community, and therefore would significantly benefit the historic resource. Measure 6 provides the greatest amount of flood protection, whereas Measure 8 leaves unprotected a portion of the extreme north side of town, which includes the historic Millard house. Because it is felt that the flood protection offered by these two measures will encourage restoration and rehabilitation of some lower-elevation historic structures which have been neglected to date, major beneficial effects would be expected.

4.2.8 Measure 20.

Measure 20 removes structures subject to damage from 10-year frequency floods, but results in neglect of structures which would be damaged by less frequent flooding, among which would be included 82 of Ste. Genevieve's historic buildings. This constitutes an adverse effect as described for the no-action alternative. Relocation of several structures constitutes alteration of part of the National Register

property, and is thus an adverse effect; further losses of historic significance could result from demolition of some "non-historic" structures because recent modifications sometimes mask the evidences of earlier construction.

4.2.9 Measure 21.

Measure 21 proposes relocation of those historic structures which lie within the 1973 flood zone. It would result in alteration of part of the historic district, an introduction, through relocation, of out-of-character visual elements to the French structures, and in isolation of these from surrounding areas of the town and its setting. Since it provides no structural protection, the measure would furthermore result in neglect, jeopardizing other historic values in the district. For all these reasons, Measure 21 would constitute an adverse effect.

4.2.10 First Iteration Conclusions.

In conclusion: historic preservation interests and flood protection ("project") interests are both important in the public eye. Cultural resource effect assessments have been made for each protection measure and the "no action" alternative; these should be used to augment economic BCR's in the following manner.

Cultural resource effect assessments for Measures 1 through 5, 7, 20, and 21 indicate conflict between historic preservation and flood

protection interests for these measures; therefore, they are culturally not feasible and they should be rejected regardless of their economic BCR's. Cultural resource effect assessments for Measures 6 and 8 indicate substantial agreement between historic preservation and flood protection interests. Economic BCR's for these measures are not near unity; however, a "no action" alternative conflicts completely with the public interest because it would be adverse to both the historic preservation and the flood protection interests. Therefore, "no action" should not be recommended on the basis of low economic BCR's for measures 6 or 8. The one measure among Measures 6 and 8 having the highest economic BCR should be recommended.

4.3 SECOND ITERATION

4.3.1 Measures 9, 10, and 11.

Significant beneficial effects would accrue from any of these three levee measures. Like Measure 6, Measures 9, 10, and 11 provide complete Mississippi River flood protection without adverse effects to the surviving historical architecture in Ste. Genevieve. Measures 10 and 11 represent "best possible" Mississippi River flood protection from the standpoint of historic buildings because they tie into high ground south of Valle Spring Branch, thereby protecting the Vital St. Gemme house, an outlying French colonial residence. Any one of Measures 9, 10, or 11 would be likely to stimulate restoration and preservation opportunities and objectives as identified earlier in this Appendix.

Creek flooding would remain a problem even with one of these levee measures in place. However, during high Mississippi River stages, creek water could be ponded behind the levee to elevation 383.5 without reaching the first floor of any historic buildings.

4.3.2 Measures 12 and 13.

These measures provide protection from interior flooding, in a manner compatible with the historical resource. With Measure 12 in place, damage estimates are improved for all but one historic building subject to South Gabouri Creek flooding. No historic building would experience first floor damage unless a flood more severe than a 25-year event occurred. Measure 12 would not result in direct impact to any historic properties. The proposed small levee at the east end of town would not constitute an adverse visual effect, and any undesirable visual effects of channel widening would be cancelled through time as vegetation grows back. In fact, early photographs of Ste. Genevieve suggest that the South Gabouri Creek channel was, originally, nearly or actually as wide as it would be with Measure 12 in place.

Measure 13 would accomplish even greater benefits to historic buildings. Again, damage estimates are improved for all but one historic building with Measure 13 in place. Only floods more severe than a 50-year event would reach the first floor of any historic building and 24 historic buildings would no longer be within the Standard Project Flood zone. The proposed small levee between Main and Fourth Streets has

actually been constructed by the City of Ste. Genevieve and does not constitute an adverse visual effect. The same remarks made about the appearance of the Measure 12 channel apply to Measure 13.

The level of protection provided by Measures 12 and 13 represents an optimal solution. Greater levels of protection could not be realized without direct impact to historic properties. Specifically, greater levels of protection would require direct adverse impacts to at least 4 historic structures on North Gabouri Creek and at least 10 historic structures on South Gabouri Creek. On a theoretical curve that would relate economic benefits, cultural benefits, and level of protection, the 25-year level would be an inflection point. That is, economic benefits (not necessarily BCR's) and cultural benefits increase together up to the 25-year flood protection level, past which point cultural benefits fall off and become detriments.

4.3.3 Measures 18 and 19.

Measures 18 and 19 accomplish very minor flood protection benefits, but in a manner compatible with the historical resource. Damage estimates are improved for 6 historic buildings within the 50-year (without project) flood zones for both creeks. Clearing and snagging would not directly affect any historic properties, and indirect visual effects would not be adverse. However, since changes in hydrologic profiles are slight, since many historic buildings remain subject to high frequency floods, and since no historic buildings are actually removed

from UDF or SPF flood zones, Measures 18 and 19 have the same adverse effect as the "no action" measure considered in the First Iteration--neglect that may result in deterioration of the National Register property.

4.3.4 Measure 22.

Measure 22 would provide 25-year tributary flood protection for all historic homes on North Gabouri Creek and South Gabouri Creek (See APPENDIX A). The cultural benefits of Measure 22 are therefore very minor. The fact that hydrologic profiles would not be changed by Measure 22 would prove indirectly detrimental to the historic resource if a flood larger than a 25-year event were to occur.

4.3.5 Second Iteration Conclusions

Measures 9 through 13, 18, 19, and 22 all provide flood protection in ways compatible with the historic preservation interest. For Mississippi River flood protection, either Measures 10 or 11 would be preferred to Measure 9 because they protect the Vital St. Gemme house. For interior flood protection, Measures 18 and 19 are least preferred because they leave 13 historic buildings subject to 25-year or more frequent events. Measure 22 would provide 25-year protection (with residual basement flooding) to all historic homes but would have no effect on less frequent events. Therefore, Measures 12 and 13 are preferred for interior flood protection because they provide 25-year

protection for all buildings, and because they partially reduce hazards of less frequent floods.

SECTION 5 - RECOMMENDATIONS

Flood protection at Ste. Genevieve has a cultural purpose of substantial significance. St. Louis District's planning objectives include protection and enhancement of the historic values at Ste. Genevieve, objectives which can be accomplished only with flood protection measures designed to be compatible with the historical resource. This qualification entails that Measures 18 and 19 are culturally not feasible, because although they are not directly incompatible with the historic resource, they do not provide flood protection, even for frequent events. Measure 22 has similar status, but at least it provides 25-year protection from tributary flooding. Measures 20 and 21 are both incompatible with the historical resource and insufficient to protect historic buildings from high frequency flood events; therefore, they are not culturally feasible. Measures 1 through 5 and 7 protect many historic buildings from flooding, but do so in a manner incompatible with the historical resource. They also are culturally not feasible.

Measures 6 and 8 through 11 provide complete or near complete protection of historic buildings from Mississippi River flooding, and are designed to be compatible with the historical resource. Measures 9, 10, and 11 are design modifications of Measures 6 and 8, made following

requests of local interests. They are culturally feasible. Measures 12 and 13 provide the best levels of protection from interior flooding that it is possible to achieve in a manner compatible with the historical resource. These measures are considered culturally feasible, with the caveat that both Mississippi River and creek flood protection must be provided for the planning objectives to be achieved. Therefore, a culturally feasible plan will combine Measures 12 and 13 with one of Measures 9, 10, or 11.

In summary, the No Corps Action Plan and Plan 4 (the NED plan) are not culturally feasible. No Corps Action would provide no flood protection and would constitute neglect that will result in the deterioration or destruction of the National Register property. Plan 4 would provide minor benefits relative to tributary flooding but would provide no protection from Mississippi River flooding. Just like the No Corps Action Plan, the NED plan would constitute neglect leading to deterioration or destruction of the National Register property; therefore, both Plan 4 (the NED plan) and the No Corps Action Plan are adverse effects as defined by the Advisory Council on Historic Preservation.

Plans 1, 2, and 3 are all culturally feasible because each provides a beneficial effect through flood protection, and each does so in a manner compatible with the National Register property.

One further stipulation must be made. Flood protection provided by a plan combining Measures 9, 12, and 13 (Plan 1) or Measures 10, 12 and 13 (Plan 2) or Measures 11, 12, and 13 (Plan 3) will constitute a beneficial affect on the historical resource, as defined by the Advisory Council on Historic Preservation. However, any such plan will protect formerly flood-prone undeveloped lands. The Corps of Engineers would impose constraints on new development of such lands, or obtain assurances from local officials that they will impose such constraints, in order to ensure that flood protection will not inadvertently invite developments out of character with the historic district.

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

APPENDIX F

ECOLOGICAL RESOURCES

STE. GENEVIEVE, MISSOURI

APPENDIX F

ECOLOGICAL RESOURCES

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ECOLOGICAL RESOURCES

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STE. GENEVIEVE, MISSOURI

APPENDIX F

ECOLOGICAL RESOURCES

SECTION 1 - ENVIRONMENTAL SETTING

The study area includes a portion of the Mississippi River floodplain which is primarily devoted to agricultural crop production. A few remnants of forest exist adjacent to the Mississippi river bank, the North and South Gabouri Creeks, Valle Spring Branch, and the Mississippi Slough.

Adjacent to the floodplains are the rolling Ozark hills drained by the three creeks. Most of the uplands are a patchwork of forest and pasture with forest being more extensive in the headwaters. Crop production is limited to the narrow creek floodplains.

The town itself begins on the edge of the floodplain and extends into the uplands. North and South Gabouri Creeks flow through the town.

Wildlife habitat quality varies from good to excellent in the headwaters to fair to poor in the urban area and in the intensively farmed floodplain.

1.1 PHYSICAL RESOURCES

1.1.1 Air Quality.

The operations of the Mississippi Lime Company generate airborne particulates; however, the Missouri Department of Natural Resources reports that there are no problems in air quality in the study area.

1.1.2 Noise.

When contacted, the Missouri Department of Natural Resources related that there have been no noise related complaints from the study area. The State of Missouri does not have any regulations that apply to noise.

1.1.3 Climate.

The southern Missouri region experiences a warm temperate rainy climate with hot summers and comparatively mild winters. The average precipitation at Farmington, Missouri, is approximately 42 inches. The mean average temperature at Farmington is 56° F with a July mean of about 76° F and a January mean of about 33° F.

1.1.4 Soils and Prime Farmland.

Modern soil surveys have been prepared by the U.S. Soil Conservation Service for Ste. Genevieve County. Engineering

interpretations for each soil unit encountered are include in these soil surveys.

The predominant soil units in the project area are Fults Silty Clay Loam, Haynie Silt Loam, Beaucoup Silty Clay Loam, Menfro Silt Loam, and Haymond Silt Loam. According to the Unified Soil Classification System these soils are classified as lean clays, silts, silty clays, clayey sands, and silty sands. These units represent deep, moderately well drained soils with generally low strengths. The primary usage of these units is crop production, pasture, and wildlife habitat.

Due to flooding, these units have limitations for most urban uses. According to the Soil Conservation Service Survey, most soil units within the project limits have moderate to severe limitations when developed, unless the soils are first modified by such measures as compaction and drying.

A study of the project area for material suitable for embankment construction and other engineering uses has been made. The study revealed that enough suitable material is available within the project limits.

Most of the soils found within the overall project area do not qualify as potential prime farmland because of topography, soil type and/or frequency of flooding. The soil units that do meet the basic requirements are shown in TABLE F-1.

TABLE F-1

Prime Farmland Soil Units Within

Project Boundaries

1.	Ashton Silt Loam
2.	Beaucoup Silty Clay Loam
3.	Carr Fine Sand
4.	Fults Silty Clay Loam
5.	Haymond Silt Loam
6.	Haynie Silt Loam
7.	Wabash Silty Clay
8.	Wilber Silt Loam

1.1.5 Mississippi River.

The Mississippi River is important as a biological, transportation, and recreational resource. The Corps of Engineers maintains a nine-foot channel for commercial navigation and the river corridor is also important for fish and wildlife, including bald eagles and waterfowl. It is the major source of flooding for the town.

1.1.6 Tributary Streams.

North and South Gabouri Creeks start in the Ozark uplands, flow through the town and join in the floodplain to flow into the Mississippi River. They are also a source of flooding in Ste. Genevieve. Their fish and benthic fanua are discussed in a study done by the U.S. Fish and Wildlife Service in APPENDIX J. South Gabouri Creek receives discharges from the Mississippi Lime Company.

Valle Spring Branch drains the southern portion of the study area. It is intermittent except after storms. The portion of the creek flowing through the floodplain has been channelized and has very little value to the fish and wildlife. The aquatic resources of this stream are also discussed in APPENDIX J.

1.1.7 Water Supply.

The water supply wells are located in the floodplain and groundwater is pumped for use. They are not subject to flooding except in an event with a greater than 100 year frequency.

1.1.8 Wetlands.

Wetlands in the study area are confined to the Mississippi River floodplain. The most significant wetland is the Mississippi Slough which is a tree lined old river channel 38 acres in size. Under the classification system of the U.S. Fish and Wildlife Service (Cowardin et al. 1979) it is classified as a fresh water, permanently flooded, unconsolidated (mud) bottom wetland.

A number of acres of cropland are flooded periodically, especially in the spring. These areas are not wet long enough for wetland vegetation to become established and are farmed during most years. They are classified as fresh water, temporarily flooded, emergent wetlands.

1.1.9 Water Quality.

North Gabouri, South Gabouri and Valle Spring Branch creeks were sampled and visually inspected in December 1982 to determine base line water quality conditions and evaluate potential water quality impacts of the proposed project.

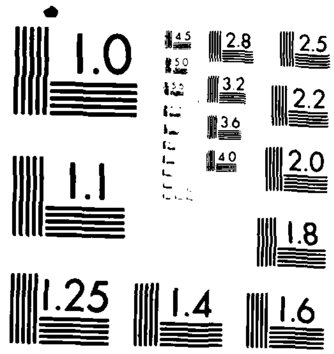
Fourteen water quality parameters were studied at five sites (see PLATE F-1 and TABLE F-2). A map showing the locations of the water quality sampling sites is shown in PLATE F-1 in VOLUME THREE of this report. Sampling was conducted at the same sites as the U.S. Fish and Wildlife Service's aquatic inventory; however, water quality samples were not taken at the confluence of North and South Gabouri Creeks because this area was flooded. A description of each site is provided in APPENDIX J. During the sampling period the streams were being influenced by rainfall.

The streams are unclassified in Chapter 7 of the Missouri Clean Water Commission's water quality standards. This indicates that these streams have a low base flow and generally cease flow during dry periods. As such, these streams have only to meet the General Criteria of Missouri's water quality standard (No. 10 CSR20-7.031) which states:

> (3) General Criteria: The following water quality criteria shall be applicable to all waters of the state at all times. No water contaminant, by itself or in combination with other substances, shall prevent the waters of the state from being -
>
> (a) free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits, or interfere with beneficial uses;

AD-A161 612 STE GENEVIEVE MISSOURI FEASABILITY REPORT (FLOOD CONTROL STUDY FOR HISTOR (U) ARMY ENGINEER DISTRICT ST LOUIS MO J ZEREGA ET AL JUN 84 4/7

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TABLE F-2

WATER QUALITY PARAMETERS

Parameter	1 North Gabouri (Lime Kiln Park Road)	2 North Gabouri (Main St. Bridge)	3 South Gabouri	4 South Gabouri (South Main St.)	5 Valle Branch (Hwy 61)	State Standard
	Sample Site Location					
Air Temp (°C)	5	5	3	4.5	3	
Water Temp (°C)	10	11	10	11	11	
Flow (cfs)	10	(Backwater) 0	5	5	(Backwater) 0	
Dissolved Oxygen (mg/1)	10.5	10.1	10.9	10.9	8.5	6 mg/1
pH	6.9	7.0	7.3	8.1	7.0	6.5-9.0
Turbidity (NTU)	81	93	21	202	113	
Conductivity (umHos/cm)	411	430	401	459	506	
Hardness (mg/1)	200	206	195	213	238	
Chlorides (mg/1)	7.5	8.5	7.0	28.5	10.8	
COD (mg/1)	11	14	9	20	14	
Total Suspended Solids (mg/1)	68	62	17	199	84	
Total Dissolved Solids (mg/1)	263	280	256	295	327	

TABLE F-2 (Cont'd)

WATER QUALITY PARAMETERS

Sample Site Location

Parameter	1 North Gabouri (Lime Kiln Park Road)	2 North Gabouri (Main St. Bridge)	3 South Gabouri	4 South Gabouri (South Main St.)	5 Valle Branch (Hwy 61)	State Standard
Total Volatile Suspended Solids (mg/l)	11	10	5	22	12	
Date Sampled	12/28/82	12/28/82	12/28/82	12/28/82	12/28/82	
Time Sampled	10:57	11:15	12:28	11:30	13:00	

(b) free from oil, scum, and floating debris in sufficient amounts to be unsightly or interfere with beneficial uses;

(c) free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or taste, or interfere with beneficial uses; and

(d) free from substances or conditions that have a harmful effect on human, animal, or aquatic life.

The water quality of these streams met all of the general criteria, except for the reach of South Gabouri Creek downstream from the Mississippi Line Company mining operation. The mining operation is located just upstream from Highway 61. Occasionally mine wastes are discharged into South Gabouri Creek and deposit in the stream bed. Runoff from this area during storm events also causes an increase in solids, chlorides and COD . This is detrimental to the creek but is an intermittent problem. Except for the above mentioned area, North and South Gabouri Creeks are fairly typical of small streams draining agricultural and urban watersheds.

1.1.10 Sewage Lagoon.

The sewage lagoon is located in the floodplain. It is subject to flooding on an 8 year frequency interval and was flooded in 1973. The sewage lagoon was severely damaged by the December, 1982 flood. The city plans to abandon the sewage lagoon and construct a sewage treatment plant that would not be damaged by flooding up to a 100 year frequency.

1.2 BIOLOGICAL RESOURCES

1.2.1 Endangered Species.

For endangered species compliance, see APPENDIX I.

a. Federal.

(1) Bald Eagle (Haliaeetus leucocephalus). The bald eagle is primarily a winter visitor in the Ste. Genevieve area. They primarily occur along the Mississippi River catching fish and perching in large riparian trees. The Illinois Natural History Survey (Belrose, et al. 1973; Sanderson, et al. 1974-1982) has made aerial waterfront surveys (including bald eagles) for the last ten years. In the winter of 1981-82 as many as 45 eagles were observed at one time between Crystal City, Missouri, and Chester, Illinois. There is no known critical bald eagle habitat in the study area.

(2) Indiana Bat (Myotis sodalis). Potential Indiana bat summer habitat exists along portions of the tree lined streams in the study area as well as along the Mississippi Slough. Females and young form maternity colonies in this type of habitat between mid-May and mid-September. Populations average about 75 bats per kilometer of

suitable habitat (Brady, In Preparation). There are no known nursery colonies in the study area.

The habitat is not considered to be essential because of the disturbed urban environment, the mining discharging into South Gabouri Creek and the scarcity of prime tree cover (i.e., mature, riparian tree corridor wider than 30 meters on each side, overhanging the creek).

(3) Fat Pocketbook Pearly Mussel - (Potamilus capax). The only recent records in Missouri for this species are from two localities on the upper Mississippi River (Nordstrom et al, 1977). Buchanan (1983) reports that the species has not been reported south of Saverton, Missouri since 1965. He believes that the Mississippi River south of St. Louis has become unsuitable for this species because of pollution, channelization and maintenance dredging.

(4) Higginsi' Eye Pearly Mussel - (Lampsilis higginsi). This species was formerly found in the Mississippi River (Nordstrom et al, 1977). Buchanan (1983) believes that the Mississippi River south of St. Louis has become unsuitable for this species also. Havlik (1980) reports that this species has never been found downstream of Louisiana, Missouri, and therefore, never occurred in the study area.

b. State. Species considered rare and endangered by the Missouri Department of Conservation which may occur in the study area are described below.

Group	Common Name	Habitat	Status
Plants			
Bassania trilobata	Liverwort	shaded sandstone, base of cliff	Endangered
Bryoxiphium norvegicum	Sword Moss	on shaded, vertical, moist sandstone	Endangered
Carex tonsa	Shaved Sedge	sandstone outcrops & bluffs	Endangered
Dennstaedtia punctilobula	Hay-scented Fern	shaded ledges of sandstone bluffs & ravines	Rare
Draba aprica	Whitlow Grass	valley woodlands	Endangered
Goodyera pubescens	Rattlesnake Plantain	sandstone or chert woodlands	Rare
Ilex verticillata var padifolia	Winterberry	granite sites on lower slopes & streamsides	Rare
Isopterygium dischaceum	Moss	moist shaded sandstone	Endangered
Isotria verticillata	Large Whorled Pogonia	woodland slopes in deep ravines or on level ground	Rare
Lycopodium lucidulim var lucidulum	Shining Clubmoss	shaded crevices & ledges of sandstone bluff	Rare
Lycopodium obscurum var dendroideum	Round-branched Ground Pine	shaded sandstone bluffs	Endangered
Lycopodium selago var patens	Fir Clubmoss	shaded crevices of sandstone bluffs	Rare
Lycopodium tristachyum	Ground Cedar, Ground Pine	bluffs of sandstone in pine woods	Endangered
Malaxis unifolia f. unifolia	Green Adder's Mouth	dry, rich woodlands & valley floors bordering streams	Rare
Marsupella sullivantii	Liverwort	shaded sandstone where seepage is abundant	Endangered

Group	Common Name	Habitat	Status
Plants (Cont'd)			
Microlepidozia sylvatica	Liverwort	in crevices of sandstone	Endangered
Mimulus glabratus var *fremontii*	Monkey Flower	springs & wet ledges along bluffs	Rare
Philonotis capillaris	Moss	edges of creek	Endangered
Phlox maculata var *pyramidalis*	Wild Sweet William	swampy meadows	Rare
Rhabdoweisia denticulata	Moss	on vertical, shaded sandstone	Endangered
Isopterygium muellerianum	Moss	shaded sandstone	Endangered
Rhododendron roseum albidum	Azalea	wooded ravines & north-facing wooded bluffs	Rare
Scleria nitida	Shining Nut-rush	sandy slopes along spring branches & on dry sandstone rock exposures	Rare
Sphagnum capillaceum var *tenerum*	Moss	moist soil of sandy slopes	Endangered
Syrrhopodon texanus	Moss	shaded soil & vertical sandstone	Endangered
Thamnobryum alleghaniense	Moss	on moist sandy soil	Endangered
Viola macloskeyi shady bluffs var *pallens*	Smooth White Violet Rare		moist,
Invertebrates			
Apocrangonyx subtilis	Amphipod	cave	
Zosteractis	Millipede	caves	
Interminata			

Group	Common Name	Habitat	Status
Fishes			
Obovaria olivaria	Hickory-nut	Meramec & Mississippi Rivers	Rare
Lepisosteus spatula	Alligator Gar	Mississippi River	Rare
Hybopsis gelida	Sturgeon Chub	channels of large, silty plains streams	Rare
Hybopsis meeki	Sicklefin Chub	channels of large, turbid rivers	Rare
Amphibians & Reptiles			
Hemidactylium woodland sites *scutatum*	Four-toed Salamander Rare		wet
Rana sylvatica	Wood Frog	moist woodlands	Endangered
Mammals			
Mustela frenata	Long-tailed Weasel	woodlands, old fields & fence rows near water	Rare
Birds			
Circus cyaneus	Marsh Hawk	tall grass prairies	Endangered
Haliaeetus leucocephalus	Bald Eagle	migrant species	Federally Endangered

1.2.2 Aquatic Resources.

The following description of the aquatic community is based on a survey conducted by the U.S. Fish and Wildlife Service (APPENDIX J). See PLATE F-1 for locations of sampling sites.

a. **Fisheries**. Twenty-five species of fish were collected or observed from two sites in North Gabouri Creek. Central stoneroller

(*Campostoma anomalum*), green sunfish (*Lepomis cyanellus*), and rainbow darter (*Etheostoma caeruleum*) were the most abundant species at the upper sampling site and black bullhead (*Ictalurus melas*), emerald shiner (*Notropis atherinoides*), and bluegill (*Lepomis machrochirus*) at the lower site. A fishable population of sport fish, mainly centrachids, exists in the stream but most specimens collected were not of harvestable size. Rainbow darters, which are not tolerant of turbidity, were found in the upper part of the stream. Most other species taken are moderately tolerant of adverse environmental conditions. The presence of juvenile carp (*Cyprinus carpio*), smallmouth buffalo (*Ictiobus bubalus*), and freshwater drum (*Aplodinotus grunniens*) indicates the area serves as a nursery area for the Mississippi River.

Thirteen species of fish were taken from two sites in South Gabouri Creek. Green sunfish and central stoneroller were most abundant at the upper sampling site and, green sunfish and golden redhorse (*Moxostoma erythurum*) at the lower sampling site. Mississippi River fishes such as shortnose gar (*Lepisosteus platostomus*), carp, smallmouth and bigmouth buffalo (*Ictiobus cyprinellus*) were found in the lower section of stream. A fishable population of green sunfish and largemouth bass (*Micropterus salmoides*) exists in the upper end of this stream but harvestable-size fish were rare.

Limestone mining wastes appear to have some affect on the lower section of South Gabouri Creek. Fish population in the lower section of stream were more diverse than those of the upper section. But this

greater diversity is attributable to the presence of adult and juvenile fish indigenous to the Mississippi River. Fish populations in the lower section are substantially less dense that the upper section.

The calm water habitat at the confluence of the Gabouri Creeks attracts fish from the Mississippi River. Eleven species were taken at this site. Of these, bigmouth buffalo, gizzard shad, carp, and river carpsucker (Carpidoes carpio) were most abundant. The site appears capable of supporting a commercial fish population. A channel catfish (Ictalurus punctatus), 3 white bass (Morone chrysops), and a paddlefish (Polydon spathula), all of which are important sport and/or commercial species, were taken. Deep water levels limited sampling efficiency at this site.

Black bullhead, gizzard shad (Dorosoma cepedianum), largemouth bass, and green sunfish (in that order of abundance) were taken from a sampling site on Valle Spring Branch.

Past channelization and extremely low water levels have limited suitable fish habitat. Sampling efficiency at this site was reduced by the difficulty experienced in working the soft bottom. Because of this, the list of species collected is considered incomplete. The aquatic habitat value of the lower section of Valle Spring Branch appears to be limited by past channelization and periodic low water levels.

Based on the Sannon-Weaver Diversity and MacArthur's Evenness Indices (Weber 1973), fish populations in North Gabouri are generally more diverse than those of the South Gabouri. Diversity and evenness indices from the lower sampling stations on both streams are higher than the upper stations, due to the presence of Mississippi River fishes. Valle Spring Branch data displayed a diversity index indicating a stressed environment. However, these low values are due, at least in part, to poor sampling efficiency.

b. Benthos. Sixteen benthic taxa were taken from North Gabouri Creek. *Gammarus pseudolimnaeus* was the most abundant taxon taken at the upper sampling site and chironomids, oligochaetes, and mayflies (*Caenis* sp.) at the lower site. Thirty-two benthic taxa were collected at South Gabouri Creek. Mayflies (*Stenonema* sp. and *Caenis* sp.) and *Gammarus pseudolimnaeus* were predominant at the upper site and mayflies (*Caenis* sp.), chironomids, cranefly larva (Tipulidae), and snails (*Physa* sp.) at the lower site. The sample taken at Valle Spring Branch was comprised entirely of oligochaetes which were densely populated. No organisms were taken at the confluence of the Gabouris. However, sampling efficiency at this site was poor. Chironomids and oligochaetes normally inhabit soft substrates of the type found at the site.

South Gabouri Creek appears to maintain a more diverse and evenly distributed population of macroinvertebrates than North Gabouri Creek. The indices further suggest that the macroinvertebrate populations in North Gabouri Creek are more stressed than those of the

South Gabouri. Low diversity and evenness values reported of North Gabouri Creek may have resulted from an earlier hog manure spill. Macroinvertebrates in the Valle Spring Branch appear to be highly stressed. No assumptions are made regarding the confluence of the Gabouris, since no macroinvertebrates were collected at the site.

1.2.3 Terrestrial Resources.

TABLE F-3 shows the area of the habitat types for the Impact area.

TABLE F-3

Habitat Types for the Ste Genevieve Impact Area:
Present (1982) Conditions

Habitat	Acres
Urban	334
Crop*	1,040
Floodplain Forest	138
Upland Forest	66
Pasture	40
Wetland	39
Open Water	5
Total	1,662

* Includes 595 acres of prime farmland.

The town of Ste. Genevieve is an urban/suburban area where most of the wildlife habitat is floodplain forest along the riparian corridor of North and South Gabouri Creeks. The stream corridors are heavily

vegetated with trees and shrubs, many of which overhang the bank. The corridors provide good habitat for some birds such as robins, cardinals, bluejays, and brown thrashers (and many others), as well as small mammals such as muskrat, opossum, raccoon, and cottontail. A variety of reptiles and amphibians also would be found in this area.

The Mississippi River floodplain is primarily composed of cropland with corn, wheat and soybeans being the major crops. The most valuable wildlife habitat is the floodplain forest that occurs primarily along the streams (riparian corridors) and the Mississippi Slough. These strips of forest provide important cover and travel lanes especially in the winter when there is no cover available in the crop fields. The interspersion of habitat types is also important to provide habitat for a greater variety of wildlife species.

Wildlife species associated with the agricultural floodplain include morning dove, bobwhite quail, cottontail, white-tailed deer, raccoon, red-tailed hawk, and black rat snake.

The wetlands such as the Mississippi Slough and the seasonally flooded agricultural fields provide resting and feeding areas for migratory waterfowl in the spring and fall. They also provide feeding habitat for wading birds such as the great blue heron and common egret.

The remaining wildlife habitat consists of small area of upland forest and pasture adjacent to the edge of the Mississippi River floodplain.

1.2.4 Games Species.

a. Big Game.

Ste. Genevieve County has one of the better harvests of deer and turkey in Missouri. Most of the town and intensively farmed floodplain, does not provide good habitat for these species.

In 1981, the deer harvest for the county was 1050 and the turkey harvest was 795 which was the second highest turkey harvest in the state. (Urich, 1982)

b. Small Game.

The principal small game species that are found in the study area are cottontail rabbit, fox and gray squirrel, bobwhite, and mourning dove. Ste. Genevieve County is included in the North East Ozark Boarder zoogeographic region by the Missouri Department of Conservation for the purpose of recording harvest data. This region is below the statewide bag (number of animals harvested per day) for rabbit and quail, above for squirrel and almost the same for dove.

The study area would provide fair habitat for rabbits and quail in the floodplain near the edges of the forest strips; squirrel habitat is poor because of the lack of forest cover and the lack of mast (nut)

bearing trees. The large agricultural fields and the waste grain provide good dove habitat, especially during the fall hunting season.

c. Waterfowl.

The hunting success for waterfowl in the North and East Ozark Boarder Region is above the state average. In the study area, waterfowl use would depend of the water level of the Mississippi River. When the river is high and the crop fields are flooded, waterfowl habitat is plentiful; however, when the river is low, there is little good habitat available except for the Mississippi Slough.

1.2.5 Habitat Evaluation.

Due to the relatively poor quality of the existing habitat in the study area, a habitat based evaluation was not considered to be important by either the St. Louis District, U.S. Fish and Wildlife Service, or Missouri Department of Conservation. In order to fulfill the National Economic Development evaluation, a user day method was used to evaluate the wildlife monetary value to the study area.

The significant habitat type changes would be from cropland to marsh (borrow pits) and levee. For purposes of this monetary habitat value evaluation, only two broad categories were evaluated:

a. Openland. This category includes cropland and levee as well as the narrow bands of bottomland forest and stream channels that occur in the floodplain. All of the openland is presently in the 5 year floodplain.

b. Marsh. The borrow pits that would be used to build the levees would be managed as marshes. Under the U.S. Fish and Wildlife Service Classification, they will be semi-permanently flooded, fresh water, emergent wetlands.

TABLES F-4 and F-5 are based on the Water Resources Council's method of arriving at a monetary value for a particular type of recreation activity.

TABLE F-6 displays the primarily consumptive values of the major habitat types involved in this study - open land and marsh.

1.3 AESTHETICS

The most significant aesthetic resources in the study area are the historical French colonial homes. Many of these sites are open to the public and are visited by thousands of people each year. Some of the houses have attractive gardens.

TABLE F-4

Evaluation* of Big Game/Waterfowl Hunting

(Open Land and Marsh)

Criteria	Evaluation	Point Value	Point Range
Recreation Experience	Moderate use, other users evident and likely to interfere with use.	7	0-30
Availability or Opportunity	Several within 1 hour travel time; a few within 30 min travel time.	2	0-18
Carrying Capacity	Minimum facility development for public health and safety.	1	0-14
Accessibility	Fair access, fair roads to site, fair access, poor roads within site.	8	0-18
Environmental Quality	Average esthetic quality; factors exist that lower quality to a minor degree.	5	0-20
		23	0-100

* See Water Resources Council, 1979, Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C); Final Rule. Federal Register 44 (242): 72962-72965.

TABLE F-5

Evaluation* of Small Game Hunting

(Open Land and Marsh)

Criteria	Evaluation	Point Value	Point Range
Recreation Experience	Several general activities.	8	0-30
Availability or Opportunity	Several with 1 hour travel time; few within 30 min travel time.	2	0-18
Carrying Capacity	Minimum facility development for public health and safety	1	0-14
Accessibility	Fair access, fair road to site, fair access, poor roads within site.	8	0-18
Environmental Quality	Average esthetic quality factors exist that lower quality to minor degree.	5	0-20
		24	0-100

* See Water Resources Council, 1979, Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C); Final Rule. Federal Register 44 (242): 72962-72965.

TABLE F-6

Monetary Value of Wildlife Habitat

Habitat type 1	Consumptive Use 2	Species 3	Population per acre 4	Harvest Rate 5 (%)	Harvest Potential per acre for one 6(4X5)	Recreational Use: Effort (MD) for one 7	Recreational Use: MD/acre 8(6X7)	Recreational Use: $/MD 9 [7]	Commercial Use $/Pelt 10	Subtotal $/acre/year (6X10) or (8X9) 11
Marsh	Small Game	Rabbit	.20 [1]	.50 [1]	.10	.88 [2]	.09	$ 2.72		$ .24
		Quail	.05 [1]	.60 [1]	.03	.52 [2]	.02	2.72		.05
		Snipe	.20 [1]	.50 [1]	.10	.95 [3]	.10	2.72		.27
		Rail	.10 [1]	.30 [1]	.03	.95 [3]	.03	2.72		.08
	Big Game						.01 [1]	11.09		.11
	Waterfowl [6]	Geese	5.99 [6]	.25 [6]	1.50	4.76	7.14	11.09		79.18
		Ducks	4.69 [6]	.20 [6]	.94	.85 [2]	.80	11.09		8.87
	Furbearers	Muskrat	8.00 [5]	.50 [1]	4.00				$ 6.10 [4]	24.40
		Beaver	.25 [1]	.50 [1]	.13				10.30 [4]	1.34
	Non Consumptive					1.00 [1]	2.72			
									Total	$114.54
Openland [8]	Small Game	Rabbit	.10 [1]	.50 [1]	.05	.88 [2]	.04	2.72		$ .11
		Dove	.09 [1]	.33 [1]	.03	.31 [2]	.01	2.72		.03
		Quail	.05 [1]	.60 [1]	.03	.52 [2]	.02	2.72		.05
	Big Game						.01 [1]	11.09		.11
	Nonconsumptive Wildlife Recreation						.01 [1]	2.72		.03
	Waterfowl						.01 [1]	11.09		.11
									Total	$ .44

FOOTNOTES FOR TABLE F-6

1/ Estimate.

2/ Sheriff, S.L. 1980. Performance Report Surveys and Investigation Project, Federal Aid Project No. W-13-R-34(1980). Missouri Department of Conservation.

3/ Sheriff, S.L. 1980. Woodcock value used.

4/ Erickson, D. 1981. Furbearer Harvest, 1980-81, Missouri Department of Conservation.

5/ Trippensee, R.E. 1953. Wildlife Management. McGraw-Hill Book Company, New York.

6/ Waterfowl data is for unmanaged marsh areas in Southern Illinois provided by the Illinois Department of Conservation in 1980.

7/ U.S. Water Resources Council. 1979. Reference handbook for use with Principals, Standards and Procedures for Water Resource Planning (Level C). Fiscal Year 1982.

8/ Openland includes cropland and levee as well as narrow bands of bottomland forest and stream channels that occur in the floodplain.

Other aesthetic elements include the tree lined North and South Gabouri Creeks that pass through town and the view of the Mississippi River floodplain which consists of viewing of broad expanses of cropland and lines of trees.

SECTION 2 - FUTURE CONDITIONS WITHOUT CORPS PROJECT

Changes in ecological resources are primarily based on man's effect on these resources, and this is largely based on economic conditions and population pressures which are discussed in Appendix I. Since the land use changes based on the economic evaluation are projected to be insignificant, the changes in the ecological resources are projected to be the same.

SECTION 3 - SIGNIFICANT ECOLOGICAL RESOURCES

TABLE F-7 lists those resources that are considered significant and may be impacted by flood control measures being considered. Significance is based on three types of recognition: (1) institutional, such as a law, (2) public, such as a controversy or support by a public group, and (3) technical, such as recognition based on technical or scientific criteria.

TABLE F-7

Significant Ecological Resources

That May be Impacted by Water Resource Development

Resource	Basis of Significance	Indicators
Prime Farmland	Analysis of Impacts on Prime and Unique Farmlands in EIS. Council on Environmental Quality Memorandum, 30 Aug 76	Acres/flooding frequency
Wetlands	Clean Water Act of 1977 (Public Law 92-500, as Amended, Section 404)	Acres /flooding frequency
	Executive Order 11990 Protection of Wetlands, 24 May 1977	
Water Quality	Clean Water Act of 1977	Physical, chemical, and biological properties
Endangered Species		
Federal as amended	Endangered Species Act of 1973,	Available habitat
State	Wildlife Code of Missouri	Available habitat
Floodplain Forest	Fish and Wildlife Coordination Act of 1958	Acres
Aquatic Resources	Fish and Wildlife Coordination Act of 1958	Water Quality/Length of stream
Terrestrial Resources	Fish and Wildlife Coordination Act of 1958	Acres/flooding frequency
Aesthetics	River and Harbor Flood Control Act of 1970, Public Law 91-611, Section 122	Visual effect
Sewage Lagoon	National Environmental Policy Act of 1969	Flooding frequency
Water Supply (Groundwater)	National Environmental Policy Act of 1969	Number of wells effected.

SECTION 4 - ECOLOGICAL PROBLEMS AND OPPORTUNITIES

4.1 SUGGESTIONS BY THE U.S. FISH AND WILDLIFE SERVICE

The St. Louis District transferred money to U.S. Fish and Wildlife Service under the Fish and Wildlife Coordination Act. In a series of planning aid letters (See Appendix J) and other coordination the Service listed the problems and opportunities that they observed in the study area. These are discussed below along with the St. Louis District's position on implementing these suggestions:

Problems

a. Wildlife habitat in the village of Ste. Genevieve and the Mississippi River floodplain to the east of the community is lower in value because of the highly developed nature of the area. Scarcity of habitat in these two sections of the project area is the major limiting factor for wildlife. Additional food, cover, and nesting sites is a major need.

Response: The selected plan has features such as the creation of marsh habitat from borrow pits and allowing forest vegetation to develop adjacent to diverted creeks, that will increase the wildlife habitat in this area.

b. The lower portion of South Gabouri Creek has been significantly impacted by discharges and runoff from the limestone mining operation. Fish and benthos populations appear to have been significantly reduced as a result of the discharges and runoff from the mining operation. Elimination of this pollution source would improve conditions for the fish and aquatic life in South Gabouri Creek.

Response: This concern is beyond the scope of the present study.

Opportunities

a. The proposed flood control project provides an excellent opportunity to create additional wildlife habitat. This could be done by planting wildlife - preferred vegetation on project lands. Trees and shrubs adjacent to levees and floodwalls would provide food, cover, and nesting sites for wildlife in addition to concealing the structures and making the project more aesthetically pleasing. Such plantings would also provide travel lanes between more open habitats.

Response: In designing the alternatives the St. Louis District will take every practical opportunity to incorporate these suggestions. However, we do not plan to purchase additional right-of-way which would take additional prime farmland out of production nor take residential property that is not needed for other project purposes. The right-of-way adjacent to the creek diversions will be allowed to grow in natural riparian vegetation.

b. Borrow areas could be developed into wildlife habitat. If properly constructed these areas would make ideal wetland habitat and especially benefit waterfowl during spring and fall migrations.

Response: We plan to develop the borrow areas into marsh habitat.

c. Low-flow channels on widened creeks.

Response: A man-made low-flow channel would be washed out in a few years and is not practical. Also, a natural low-flow channel will develop over time from rock and cobble moving along the stream.

d. Obtain hydraulic fill from Mississippi River maintenance dredging.

Response: Coordination with Channel Maintenance Section of the St. Louis District indicates that fill can probably be taken from areas adjacent to the Missouri side of the river where dredged material has been placed.

4.2 CORPS IDENTIFIED PROBLEMS

The Interdisciplinary Planning Team (IPT) has identified the following additional problems in the study area.

a. Possible flooding of water wells from the Mississippi River.

Response: Some of the alternatives would increase the flood protection to the water wells.

b. Periodic flooding of the sewage lagoon from the Mississippi River.

Response: Some of the alternatives would substantially increase the flood protection to the sewage lagoon.

c. Prime farmland is being flooded by the Mississippi River.

Some of the alternatives will provide substantial flood protection to a portion of the prime farmland, although the protection measures (levees) will remove some prime farmland from production (See impact discussion in Appendix F).

4.3 *CORPS IDENTIFIED OPPORTUNITIES.*

a. Widen creeks from one side only.

Response: If widening is needed to increase channel capacity, this can be done from one side to minimize the destruction of riparian vegetation. However, gabions must be placed on the side which is not widened to provide for stable banks and a channel that functions for many years.

b. Foot-Bicycle Trails.

Response: Foot-Bicycle trails can be placed on right-of-way adjacent to widened creeks and on top of levees.

c. Mowing of levee after 1 August.

Response: New levees can be mowed after 1 August to minimize destruction of nesting wildlife.

SECTION 5 - ECOLOGICAL RESOURCE OBJECTIVES

- Enhance fish and wildlife habitat where there is an opportunity.

- Avoid significant adverse impacts to endangered species.

- Enhance or create wetlands when practical.

- Protect prime farmland from flooding.

SECTION 6 - EFFECTS OF MEASURES ON ECOLOGICAL RESOURCES - FIRST ITERATION

6.1 IMPACT ASSESSMENT

The measures developed in the first iteration of the study are described in detail in APPENDIX A - PLAN FORMULATION. The impacts of these measures or the following resources were assessed; prime farmland, wetlands, groundwater, water quality, endangered species, floodplain forest, aquatic resources, terrestrial (wildlife) resources, aesthetics, sewage treatment lagoons, and water wells. The impacts of the first iteration measures are summarized in TABLE 8 and are described below.

a. No Corps Action.

(1) Prime Farmland - It will continue to be flooded periodically.

(2) Wetlands - No Significant Impact (NSI).

(3) Groundwater - NSI.

(4) Water Quality - The South Gabouri Creek will continue to be degraded by intermittent discharges from the Mississippi Line Company.

(5) Endangered Species - NSI.

(6) Floodplain forest - NSI.

(7) Aquatic Resources - NSI.

(8) Terrestrial (Wildlife) Resources - NSI.

(9) Aesthetics - NSI.

TABLE F-8

Summary of Ecological Impacts
First Iteration Measures

Ecological Resources	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8	Measures 20 and 21
Farmland	Loss of 27.2 to 53.4 ac	Loss of 16.9 to 42.9 ac	Loss of 23.6 to 53.6 ac	Loss of 4.5 to 12.3 ac	Loss of 142.5 to 324.6 ac Floodplain used for ponding area	Loss of 313.7 to 646.4 ac Floodplain used for ponding area	Loss of 89.9 to 235.5 ac Floodplain used for ponding area	Loss of 269.7 to 527.8 ac Floodplain used for ponding area	NSI
Wetlands	Gain of 17.9 to 38.3 ac	Gain of 13.2 to 34.0 ac	Gain of 14.2 to 12.3 ac	Gain of 4.5 to 12.3 ac	Gain of 34.3 to 201.7 ac	Gain of 59.3 to 382.1 ac	Gain of 34.0 to 165.0 ac	Gain of 45.4 to 286.0 ac	NSI
Groundwater	NSI	Several existing water wells will be relocated to accommodate the levee	NSI	NSI	NSI	NSI	NSI	NSI	NSI
Water Quality	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI
Endangered Species	Net gain of 300 ft. riparian Indiana bat summer habitat and 2 state listed plants	Minor increase for 2 state listed plants	Minor increase for 2 state listed plants	Minor increase for 2 state listed plants	Net loss of 200 ft. of riparian Indiana bat summer habitat. Moderate increase for 2 state listed plants	Net gain of 4800 ft. of riparian Indiana bat summer habitat and 2 state listed plants	Net loss of 200 ft. of riparian Indiana bat summer habitat. Moderate increase for 2 state listed plants	Net gain of 4800 ft. of riparian Indiana bat summer habitat and 2 state listed plants	NSI
Floodplain Forest	Loss of 0.5 to 1.0 ac	Loss of 0.1 ac	Loss of 1.2 ac	NSI	Loss of 8.5 to 12.9 ac	Loss of 4.6 to 8.8 ac	Loss of 5.2 to 6.8 ac	Loss of 1.7 to 2.6 ac	NSI

TABLE F-8 (Cont'd)

Summary of Ecological Impacts
First Iteration Measures

Ecological Resources	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8	Measures 20 and 21
Aquatic Resources	NSI	NSI	NSI	NSI	Minor adverse impact due to loss of 3000 ft. of stream	Minor adverse impact due to loss of 800 ft. of stream and cutoff of Miss. slough	Minor adverse impact due to loss of 3000 ft. of stream	Minor adverse impact due to loss of 800 ft. of stream	NSI
Terrestrial Resources	Minor increase for wetland species	Minor increase for wetland species	Minor increase for wetland species	Minor increase for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	NSI
Aesthetics	Moderate adverse impact along St. Marys Road	Major adverse impact to center of town	Major adverse impact to North Gabouri Creek	Major adverse impact to center of town	Moderate adverse impact along South Gabouri Creek	NSI	Moderate adverse impact along South Gabouri Creek	Moderate adverse impact along South Gabouri Creek	Moderately beneficial
Sewage Lagoon	NSI	NSI	NSI	NSI	NSI	Flood protection	NSI	NSI	NSI
Water Wells	NSI	Flood protection afforded	NSI	NSI	Flood protection afforded	Flood protection afforded	Flood protection afforded	Flood protection afforded	NSI

(10) Sewage Lagoons - The plant will continue to be flooded periodically by the Mississippi River.

(11) Water Wells - Wells will continue to be flooded by rare Mississippi River floods.

b. Measure 1.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. See TABLE F-9 for acres impacted.

(2) Wetlands - The borrow areas will become semi-permanently flooded, fresh water, emergent wetlands: See TABLE F-9 for acres of wetlands.

(3) Groundwater - NSI.

(4) Water Quality - NSI.

(5) Endangered Species -

(a) Federal -

1. Bald Eagle - NSI.

TABLE F-9

Land Use Changes
First Iteration Measures with Levees and Floodwalls

Measure	Urban*	Upland Forest	Floodplain Forest	Crop	Levee	Floodwall*	Potential Wetlands	New Channel
1 (1973)	- 3.5 ac	- 0.2 ac	- 0.5 ac	- 27.2 ac	+ 10.0 ac	+ 3.5 ac	+ 17.9 ac	-
1 (100 yr.)	- 4.5	- 0.3	- 0.6	- 38.8	+ 13.5	+ 4.5	+ 26.2	-
1 (Urban Design (UD))	- 5.7	- 0.2	- 1.0	- 53.4	+ 16.3	+ 5.7	+ 38.3	-
2 (1973)	- 6.9	- 1.0	- 0.1	- 16.9	+ 4.8	+ 6.9	+ 13.2	-
2 (100 yr.)	- 8.6	- 0.1	- 0.1	- 28.3	+ 5.1	+ 8.6	+ 23.4	-
2 (UD)	- 11.1		-	- 42.9	+ 8.9	+ 11.1	+ 34.0	-
3 (1973)	- 2.3	- 0.5	-	- 23.6	+ 9.9	+ 2.3	+ 14.2	-
3 (100 yr.)	- 3.8	- 0.9	-	- 32.8	+ 12.1	+ 3.8	+ 21.6	-
3 (UD)	- 6.0	- 0.7	- 1.2	- 53.6	+ 21.0	+ 6.0	+ 34.5	-
4 (1973)	- 6.0	- 0.1	-	- 4.5	+ 0.1	+ 6.0	+ 4.5	-
4 (100 yr.)	- 6.1	- 0.9	-	- 8.7	+ 0.9	+ 6.1	+ 8.7	-
4 (UD)	- 10.3	- 1.3	-	- 12.3	+ 1.3	+ 10.3	+ 12.3	-
5 1973 Std. Fill	- 8.4	-	- 9.3	- 195.9	+ 99.1	+ 8.4	+ 100.3	+ 5.8
5 1973 Hyd. Fill	- 9.8	-	- 8.5	- 142.3	+ 111.2	+ 9.8	+ 34.3	+ 5.3
5 100 yr. Std. Fill	- 9.9	-	- 12.9	- 261.7	+ 118.1	+ 9.9	+ 151.2	+ 5.3
5 100 yr. Hyd. Fill	- 9.5	-	- 8.6	- 183.4	+ 132.5	+ 9.5	+ 53.9	+ 5.6
5 UD Std. Fill	- 10.8	-	- 12.6	- 324.6	+ 130.2	+ 10.8	+ 201.7	+ 5.3
5 UD Hyd. Fill	- 10.8	-	- 11.6	- 196.0	+ 143.2	+ 10.8	+ 58.6	+ 5.8
6 1973 Std. Fill	- 2.1	-	- 6.9	- 487.4	+ 170.8	+ 2.1	+ 235.5	+ 70.0
6 1973 Hyd. Fill	- 3.0	-	- 4.6	- 313.7	+ 189.0	+ 3.0	+ 59.3	+ 70.0
6 100 yr. Std. Fill	- 2.4	-	- 8.8	- 625.1	+ 192.6	+ 2.4	+ 371.3	+ 70.0
6 100 yr. Hyd. Fill	- 3.0	-	- 6.8	- 366.3	+ 211.0	+ 3.0	+ 92.1	+ 70.0
6 UD Std. Fill	- 3.3	-	- 8.4	- 646.4	+ 202.7	+ 3.3	+ 382.1	+ 70.0
6 UD Hyd. Fill	- 4.8	-	- 7.3	396.9	+ 202.2	+ 4.8	+ 132.0	+ 70.0

* It is assumed that floodwalls will be used in urban areas.

TABLE F-9 (Cont'd)

Land Use Changes
First Iteration Measures with Levees and Floodwalls

Measure	Urban*	Upland Forest	Floodplain Forest	Crop (Prime Farmland)	Levee	Floodwall*	Potential Wetlands	New Channel
7 1973 Std. Fill	- 7.3 ac	-	- 6.6 ac	- 162.1 ac	+ 60.7 ac	+ 7.3 ac	+ 102.0 ac	+ 6.0 ac
7 1973 Hyd. Fill	- 7.0	-	- 6.0	- 99.1	+ 65.0	+ 7.0	+ 34.0	+ 6.1
7 100 yr. Std. Fill	- 7.8	-	- 5.2	199.1	+ 69.2	+ 7.8	+ 130.0	+ 5.1
7 100 yr. Hyd. Fill	- 8.9	-	- 5.4	- 89.9	+ 48.5	+ 8.9	+ 165.0	+ 5.6
7 UD Std. Fill	- 11.8	-	- 8.7	- 235.5	+ 73.2	+ 11.8	+ 165.0	+ 6.0
7 UD Hyd. Fill	- 10.7	-	- 6.8	- 105.3	+ 59.5	+ 10.7	+ 47.0	+ 5.6
8 1973 Std. Fill	- 2.5	-	- 1.7	- 419.9	+ 145.5	+ 2.5	+ 206.0	+ 70.1
8 1973 Hyd. Fill	- 2.2	-	- 1.7	- 269.7	+ 155.8	+ 2.2	+ 45.4	+ 70.2
8 100 yr. Std. Fill	- 3.0	-	- 2.1	- 470.0	+ 163.0	+ 3.0	+ 239.0	+ 70.1
8 100 yr. Hyd. Fill	- 4.6	-	- 1.8	- 297.2	+ 179.4	+ 4.6	+ 48.5	+ 70.1
8 UD Std. Fill	- 3.7	-	- 2.6	- 527.8	+ 174.3	+ 3.7	+ 286.0	+ 70.1
8 UD Hyd. Fill	- 4.3	-	- 1.7	- 322.3	+ 195.7	+ 4.3	+ 58.2	+ 70.1

* It is assumed that floodwalls will be used in urban areas.

2. Indiana Bat - 800 feet of South Gabouri Creek which is lined with riparian forest will be cut off and South Gabouri Creek will be diverted into a new channel 1100 feet long. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take from .5 to 20 years. The net effect should be a net increase in potential Indiana bat summer habitat.

(b) State - It is unlikely that any of the species listed occur in the disturbed urban area and intensively farmed land that will be impacted by this measure. However, two species of plants, primrose willow and wild sweet William, may be enhanced by the creation of wetlands.

(6) Floodplain Forest - This measure will result in the clearing of a small amount of floodplain forest. See TABLE F-9 for the acres impacted. About .5 acres of riparian forest will become established along the diverted South Gabouri Creek.

(7) Aquatic Resources - Approximately 1600 feet of South Gabouri Creek will be diverted into an 1100 feet long channel. All water-dependent species in the diverted stream segment will be destroyed when flow is initially diverted. Aquatic species would be expected to recolonize the restored stream when thc physical aspects of the channel

have stabilized and as the food chain is restored. This section of stream is currently in a degraded condition due to discharges from the Mississippi Lime Company. As such, the impacts to the aquatic community are not considered to be significant.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard duck, blue-winged teal, great blue heron, common egret, muskrat as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - The levee along St. Marys Road will be from 13.4 feet (1973 flood protection) to 20.8 feet (Urban Design flood protection) high. This will block the view of the floodplain vista.

(10) Sewage Lagoons - NSI.

(11) Water Wells - NSI.

c. Measure 2.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. See TABLE F-9 for acres impacted.

(2) Wetlands - The borrow areas will become semi-permanently flooded, fresh water, emergent wetlands. (See TABLE F-9 for acres of wetlands).

(3) Groundwater - Several existing water wells will be relocated to accommodate the levee.

(4) Water Quality - NSI.

(5) Endangered Species - Two state listed species, primrose willow and wild sweet William, may be enhanced by the creation of wetlands.

(6) Floodplain Forest - Less than one acre will be removed with this measure.

(7) Aquatic Resources - NSI.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species (see Measure 1 impacts).

(9) Aesthetics - The levee and floodwalls will reach a maximum height of from 13.6 feet (1973 flood protection) to 21 feet (Urban Design flood protection). This will replace a view of the floodplain forest

along North and South Gabouri Creeks with a view of either grass covered levees or concrete floodwalls.

(10) Sewage Lagoons - NSI.

(11) Water Wells - This measure will protect the wells at one of the three protection levels.

d. Measure 3.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. See TABLE F-9 for acres of wetlands.

(2) Wetlands - The borrow areas will become semi-permanently flooded, fresh water, emergent wetlands. (See TABLE F-9 for acres of wetlands).

(3) Groundwater - NSI.

(4) Water Quality - NSI.

(5) Endangered Species - Two state listed species, primrose willow and wild sweet William, may be enhanced by the creation of wetlands.

(6) Floodplain Forest - Slightly more than one acre will be removed for urban design flood protection.

(7) Aquatic Resources - NSI.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species (see Measure 1 impacts).

(9) Aesthetics - The levee and floodwalls will reach a maximum height of from 14 feet (1973 flood protection) to 21 feet (Urban Design flood protection) high. This will replace a view of the floodplain forest and cropland in the Mississippi River floodplain and along North Gabouri Creek with a view of grass covered levees or concrete floodwalls.

(10) Sewage Lagoons - NSI.

(11) Water Wells - NSI.

e. Measure 4.

(1) Prime Farmland - Prime farmland will be removed by the borrow area for obtaining levee material. See TABLE F-9 for acres impacted.

(2) Wetlands - The borrow areas will become semi-permanently flooded, fresh water, emergent wetlands. See TABLE F-9 for acres of wetlands.

(3) Groundwater - NSI.

(4) Water Quality - NSI.

(5) Endangered Species - Two state listed species, primrose willow and wild sweet William, may be enhanced by the creation of wetlands.

(6) Floodplain Forest - NSI.

(7) Aquatic Resources - NSI.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows the changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species (see Measure 1 impacts).

(9) Aesthetics - The levee and floodwalls will reach a maximum height of from 10.6 feet (1973 flood protection) to 18 feet (Urban Design flood protection). This will replace a view of railroad tracks, urban areas and the North Gabouri tree-lined stream corridor with mostly a concrete floodwall and some grass-covered levee.

(10) Sewage Lagoons - NSI.

(11) Water Wells - NSI.

f. Measure 5.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. See TABLE F-9 for acres impacted. As can be seen from TABLE F-9, more prime farmland is used when the standard fill method of construction is used rather than hydraulic fill.

(2) Wetlands - The borrow areas will become semi-permanently, flooded, fresh water, emergent wetlands. See TABLE F-9 for acres of wetlands.

(3) Groundwater - NSI.

(4) Water Quality - NSI.

(5) Endangered Species -

(a) Federal -

1. Bald Eagle - NSI.

2. Indiana Bat - 3000 feet of South Gabouri Creek and Valle Spring Branch lined with riparian forest will be channelized into 2800 feet of new channel. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take from 15 to 20 years. The net effect will be a light decrease in potential Indiana bat summer habitat.

(b) State - It is unlikely that any species listed occur in the disturbed urban area and intensively farmed land that will be impacted by this measure. Two species of plants, primrose willow and wild sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of from about 8 to 13 acres of floodplain forest. See TABLE F-9 for acres impacted. About 1.26 acres of riparian forest will become established adjacent to the new channel.

(7) Aquatic Resources - Approximately 3000 feet of South Gabouri and Valle Spring Branch will be diverted into a new channel 2800 feet long. The loss of riparian vegetation and ground disturbance

associated with the proposed stream realignment will have an adverse impact on the aquatic community.

Water-dependent species in the diverted stream segment will be destroyed when flow is initially diverted. Numerous secondary impacts are also associated with stream relocation. When riparian vegetation or channel morphology is modified, stream biota may be affected by elevated sediment loads, increased water temperature, disruption of aquatic food webs, and decreased habitat and species diversity. Aquatic species would be expected to recolonize the restored stream when the physical aspects of the channel have stabilized and as the food chain is restored.

Considering the existing stream condition and length of the realignment the long-term adverse impacts to the aquatic community are not considered significant.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard duck, blue-winged teal, great blue heron, common egret, muskrat as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure will have an adverse impact where the segment 5 floodwall goes up the north bank of South Gabouri

Creek in the town. The floodwall height will range from 19 feet (1973 flood protection) to 27 feet (urban design flood protection).

(10) Sewage Lagoons - NSI.

(11) Water Wells - Flood protection provided.

g. Measure 6.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. See TABLE F-9 for acres impacted. As can be seen from TABLE F-9, more prime farmland is used when the standard fill method of construction is used rather than hydraulic fill.

(2) Wetlands - The borrow areas will become semi-permanently, flooded, fresh water, emergent wetlands. See TABLE F-9 for acres of wetlands.

(3) Groundwater - NSI.

(4) Water Quality - Protects water supply wells and the sewage treatment plant from flooding.

(5) Endangered Species -

(a) Federal -

1. Bald Eagle - NSI.

2. Indiana Bat - 800 feet of Valley Spring Branch will be diverted to a new channel 5600 feet long. The old channel does not have riparian vegetation. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take from 15 to 20 years. The net effect will be a moderate increase in potential Indiana bat summer habitat.

(b) State - It is unlikely that any species listed occur in the disturbed urban area and intensively farmed land that will be impacted by this measure. Two species of plants, primrose willow and wild sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of from about 5 to 9 acres of floodplain forest. See TABLE F-9 for acres impacted. About 2.50 acres of riparian forest will become established adjacent to the new channel.

(7) Aquatic Resources - Valle Spring Branch will be blocked by a levee and diverted into a new channel, 5600 feet long which will flow directly to the Mississippi. The lower cutoff stream section will remain as a drainage ditch for the flood plain and flow into Gabouri Creek. All water-dependent species in a 800 feet section of Valle Spring Branch will be destroyed or displaced by levee construction. The diversion of 800 feet of Valle Spring Branch into a 5600 feet long channel will create additional aquatic habitat.

The Mississippi Slough and Gabouri Creek have a connection with the Mississippi River during flood. However, flows will continue during low flow periods via a gravity drain.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard, blue-winged teal, great blue heron, common egret, muskrat as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure should have little or no effect on aesthetics since the levee will not be visable from the main part of historic section of town.

(10) Sewage Lagoons - Flood protection provided.

(11) Water Wells - Flood protection provided.

h. Measure 7.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. See TABLE F-9 for acres impacted. As can be seen from TABLE F-9, more prime farmland is used when the standard fill method of construction is used rather than hydraulic fill.

(2) Wetlands - The borrow areas will become semi-permanently, flooded, fresh water, emergent wetlands. See TABLE F-9 for acres of wetlands.

(3) Groundwater - NSI.

(4) Water Quality - Protects water supply, water wells and the sewage treatment plant from flooding.

(5) Endangered Species -

(a) Federal -

1. Bald Eagle - NSI.

2. Indiana Bat - 3000 feet of South Gabouri Creek and Valley Spring Branch lined with riparian forest will be diverted to a new channel 2800 feet long. The old

channel does not have riparian vegetation. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take from 15 to 20 years. The net effect will be a slight decrease in potential Indiana bat summer habitat.

(b) State - It is unlikely that any species listed occur in the disturbed urban area and intensively farmed land that will be impacted by this measure. Two species of plants, primrose willow and wild sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of from about 8 to 13 acres of floodplain forest. See TABLE F-9 for acres impacted. About 1.26 acres of riparian forest will become established adjacent to the new channel.

(7) Aquatic Resources - Approximately 3000 feet of South Gabouri and Valle Spring Branch will be diverted into a new channel 2800 feet long. The loss of riparian vegetation and ground disturbance associated with the proposed stream realignment will have an adverse impact on the aquatic community.

Water-dependent species in the diverted stream segment will be destroyed when flow is initially diverted. Numerous secondary impacts are also associated with stream relocation. When riparian vegetation or channel morphology is modified, stream biota may be affected by elevated sediment loads, increased water temperature, disruption of aquatic food webs, and decreased habitat and species diversity. Aquatic species would be expected to recolonize the restored stream when the physical aspects of the channel have stabilized and as the food chain is restored.

Considering the existing stream condition and length of the realignment the long-term adverse impacts to the aquatic community are not considered significant.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard duck, blue-winged teal, great blue heron, common egret, muskrat as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure will have an adverse impact where the floodwall goes up the north bank of South Gabouri Creek in the town. The floodwall height will range from 19 feet (1973 flood protection) to 27 feet (urban design flood protection).

(10) Sewage Lagoon - NSI.

(11) Water Wells - Flood protection provided.

i. Measure 8.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow area for obtaining levee material. See TABLE F-9 for acres impacted. As can be seen from TABLE F-9, more prime farmland is used when the standard fill method of construction is used rather than hydraulic fill wetlands.

(2) The borrow areas will become semi-permanently, flooded, fresh water, emergent wetlands. See TABLE F-9 for acres of wetlands.

(3) Groundwater - NSI.

(4) Water Quality - NSI.

(5) Endangered Species -

(a) Federal -

1. Bald Eagle - NSI.

2. Indiana Bat - 800 feet of Valley Spring Branch will be diverted to a new channel 5600 feet long. The old

channel does not have riparian vegetation. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take from 15 to 20 years. The net effect will be a moderate increase in potential Indiana bat summer habitat.

(b) State - It is unlikely that any species listed occur in the disturbed urban area and intensively farmed land that will be impacted by this measure. Two species of plants, primrose willow and wild sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of from about 5 to 9 acres of floodplain forest. See TABLE F-9 for acres impacted. About 2.50 acres of riparian forest will become established adjacent to the new channel.

(7) Aquatic Resources - Valle Spring Branch will be blocked by a levee and diverted into a new channel, 5600 feet long which will flow directly to the Mississippi. The lower cutoff stream section will remain as a drainage ditch for the flood plain and flow into Gabouri Creek. All water-dependent species in a 800 feet section of Valle Spring Branch will be destroyed or displaced by levee construction. The

diversion of 800 feet of Valle Spring Branch into a 5600 feet long channel will create additional aquatic habitat.

The Mississippi Slough and Gabouri Creek will no longer have a connection with the Mississippi River during flood. However, flows will continue during low flow periods via a gravity drain.

(8) Terrestrial (Wildlife) Resources - TABLE F-9 shows changes in the habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard duck, blue-winged teal, great blue heron, common egret, muskrat as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure should have little or no effect on aesthetics since the levee will not be visable from the main historic section of town.

(10) Sewage Lagoons - NSI

(11) Water Wells - Flood protection provided.

j. Measure 20 and 21.

(1) Prime Farmland - NSI.

(2) Wetlands - NSI.

(3) Groundwater - NSI.

(4) Water Quality - NSI.

(5) Endangered Species - NSI.

(6) Floodplain Forest - NSI.

(7) Aquatic Resources - NSI.

(8) Terrestrial (Wildlife) Resources - There should be minor beneficial impacts where structures are removed and minor adverse impacts where structures are relocated.

(9) Aesthetics - This measure should have a moderately beneficial impact by removing structures that are subject to flooding and are often in need of upkeep.

(10) Sewage Lagoons - NSI.

(11) Water Wells - NSI.

6.2 IMPACT APPRAISAL

The impacts of each alternative for each significant ecological resource was evaluated using a numerical scale:

+3 - Major beneficial impact

+2 - Moderate beneficial impact

+1 - Minor beneficial impact

0 - No significant impact

-1 - Minor adverse impact

-2 - Moderate adverse impact

-3 - Major adverse impact

The severity of the impact was estimated using any quantitative data available (i.e., number of acres) as well as professional judgment.

The scores of each significant resource for each alternative were then added together and divided by the number of significant resources evaluated to give an average impact score. These are displayed in TABLE F-10.

SECTION 7 - EFFECTS OF MEASURES ON ECOLOGICAL RESOURCES - SECOND ITERATION

7.1 IMPACT ASSESSMENT

The measures developed in the second iteration of the study are described in detail in Appendix A - PLAN FORMULATION. The impacts were assessed for the same parameters used to assess the first iteration measures. The impacts of the second iteration measures are summarized in TABLE F-11 are described below; and land use changes for measures 9, 10, and 11 are displayed in TABLE F-12.

TABLE F-10

IMPACT APPRAISAL
FIRST ITERATION

Ecological Resource	1973	Measure 1 100 yr	UD	1973	Measure 2 100 yr	UD	1973	Measure 3 100 yr	UD	1973	Measure 4 100 yr	UD
Farm land	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Wetlands	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Groundwater	0	0	0	0	0	0	0	0	0	0	0	0
Water Quality	0	0	0	0	0	0	0	0	0	0	0	0
Endangered Species	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Flood Plain Forest	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic Resources	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial Resources	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Aesthetics	-2	-2	-2	-3	-3	-3	-3	-3	-3	-3	-3	-3
Sewage Lagoons	0	0	0	0	0	0	0	0	0	0	0	0
Water Wells	0	0	0	+3	+3	+3	0	0	0	0	0	0
Average	0	0	0	0	0	0	0	0	0	0	0	0

TABLE F-10 (Cont'd)

IMPACT APPRAISAL
FIRST ITERATION

Ecological Resource	Measure 5						Measure 6					
	1973 Std	1973 Hyd	100 yr Std	100 yr Hyd	UD Std	UD Hyd	1973 Std	1973 Hyd	100 yr Std	100yr Hyd	UD Std	UD Hyd
Farm land	-2	-2	-2	-2	-3	-2	-3	-3	-3	-3	-3	-3
Wetlands	+2	+1	+2	+1	+2	+1	+2	+1	+3	+1	+3	+2
Groundwater	0	0	0	0	0	0	0	0	0	0	0	0
Water Quality	0	0	0	0	0	0	0	0	0	0	0	0
Endangered Species	0	0	0	0	0	0	+2	+2	+2	+2	+2	+2
Flood Plain Forest	-1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1
Aquatic Resources												
Terrestrial Resources	+2		+2	+1	+2	+1	+2	+1	+2	+1	+3	+2
Aesthetics	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0
Sewage Lagoons	0	0	0	0	0	0	+1	+1	+2	+2	+3	+3
Water Wells	+1	+1	+2	+2	+3	+3	+1	+1	+2	+2	+3	+3
Average	0	0	0	0	0	0	0	0	0	0	+1	0

TABLE F-10 (Cont'd)

IMPACT APPRAISAL
FIRST ITERATION

			Measure 7						Measure 8						
Ecological Resource	1973 Std	1973 Hyd	100 yr Std	100 yr Hyd	UD Std	UD Hyd	1973 Std	1973 Hyd	100 yr Std	100 yr Hyd	UD Std	UD Hyd	Measure 20 + 21	Recreation Plan	No Action
Farm land	-2	-1	-2	-1	-2	-2	-3	-3	-3	-3	-3	-3	0	0	0
Wetlands	+2	+1	+2	+1	+2	+1	+2	+1	+2	+1	+2	+1	0	0	0
Groundwater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Quality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Endangered Species	0	0	0	0	0	0	+2	+2	+2	+2	+2	+2	0	+1	0
Flood Plain Forest	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	+1	0
Aquatic	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0
Terrestrial Resources	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2	0	+2	0
Aesthetics	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	+2	+2	0
Sewage Lagoons	0	0	0	0	0	0	+0	+0	+0	+0	+0	+0	+2	0	0
Water Wells	+1	+1	+2	+2	+3	+3	+1	+1	+2	+2	+3	+3	0	0	0
Average	0	0	0	0	0	0	0	0	0	0	+0	0	0	+1	0

TABLE F 11 SUMMARY OF ECOLOGICAL IMPACTS - SECOND ITERATION MEASURES

Ecological Resources	Measure 9	Measure 10	Measure 11	Measure 12	Measure 13	Measure 16	Measure 18	Measure 19	Measure 22
Prime Farmland	Loss of 76.0 acres. 385 ac protected	Loss of 89.3 acres. 421 ac protected	Loss of 89.7 acres. 575 ac protected	NSI	NSI	NSI	NSI	NSI	NSI
Wetlands	Gain of 79 acres	Gain of 93 acres	Gain of 108 acres	NSI	NSI	NSI	NSI	NSI	NSI
Groundwater	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI	NSI
Water Quality	NSI	NSI	NSI	Minor, temporary decrease	Minor, temporary decrease	NSI	Minor, temporary decrease	Minor, temporary decrease	NSI
Endangered Species	Minor decrease in potential Indiana bat summer habitat (1340 ft) Minor increase for 2 state-listed plants.	Minor increase in potential Indiana bat summer habitat (1180 ft) Minor increase for 2 state-listed plants.	Minor decrease in potential Indiana bat summer habitat (1570 ft) Minor increase for 2 state-listed plants.	Minor decrease in potential Indiana bat summer habitat (2857 ft)	Minor decrease in potential Indiana bat summer habitat (2059 ft)	NSI	Minor decrease in potential Indiana bat summer habitat (2112 ft)	Minor decrease in potential Indiana bat summer habitat (2270 ft)	NSI
Floodplain Forest	Net loss of 8.2 acres	Net loss of 3.3 acres	Net loss of 4.5 acres			NSI	Minor decrease by removing trees within stream banks	Minor decrease by removing trees within stream banks	NSI
Aquatic Resources	Minor decrease in tributaries lengths	Minor decrease in tributaries lengths	Minor decrease in tributaries lengths	Minor decrease 1.23 miles of stream degraded	Minor decrease 0.60 miles of stream degraded	NSI	0.40 miles of stream degraded	0.43 miles of stream degraded	NSI

TABLE F-11 - SUMMARY OF ECOLOGICAL IMPACTS - SECOND ITERATION MEASURES (Continued)

Ecological Resources	Measure 9	Measure 10	Measure 11	Measure 12	Measure 13	Measure 16	Measure 18	Measure 19	Measure 22
Terrestrial Resources	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Moderate beneficial impact for wetland species	Minor decrease in habitat value	Minor decrease in habitat value	NSI	Minor decrease in habitat diversity	Minor decrease in habitat quality	Minor increase where structures are removed
Aesthetics	Moderate increase by protecting structures from flood damage	Moderate increase by protecting structures from flood damage	Moderate increase by protecting structures from flood damage	Minor increase by removing debris from tributaries & protecting structures from flooding	Minor increase by removing debris from tributaries & protecting structures from flooding	NSI	Minor increase by removing debris from tributaries & protecting structures from flooding	Minor increase by removing debris from tributaries & protecting structures from flooding	Moderate increase by removing flooded structures
Sewage Lagoons	NSI	NSI	Flood protection provided	NSI	NSI	NSI	NSI	NSI	NSI
Water Wells	Flood protection provided	Flood protection provided	Flood protection provided	NSI	NSI	NSI	NSI	NSI	NSI

TABLE F-12 LAND USE CHANGES - SECOND ITERATION LEVEE MEASURES

Measure	Urban	Upland Forest	Floodplain Forest	Crop*	Prime Farmland	Levee	Potential Wetlands	New Channel
9	-2.6 ac	-	-8.8 ac	-241.4 ac	-76.0 ac	+167.0 ac	+ 79 ac	+6.0 ac
10	-0.5	-	4.5	-257.8	-89.3	+177.6	+ 93.6	+5.0
11	-0.5	-	-4.5	-292.6	-89.7	+200.4	+108	-

* Includes prime farmland

a. <u>Measure 9</u>

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. 76.0 acres will be removed from production.

(2) Wetlands - The borrow areas will become semi-permanently, flooded, fresh water, emergent wetlands. The net effect will be an increase of 79 acres.

(3) Groundwater - NSI

(4) Water Quality - NSI

(5) Endangered Species -

(a) Federal

<u>1.</u> Bald Eagle - NSI

<u>2.</u> Indiana Bat - 1670 feet of natural stream channel and 870 feet of wooded slough, all with riparian forest will be lost. A new 1200 foot channel will be established. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take 15 to 20 years. The net effect will be a minor decrease (1340 feet) in potential Indiana bat summer habitat.

3. State - It is unlikely that any species listed in the disturbed urban area and intensively farmed land will be impacted by this measure. Two species of plants, Primrose Willow and Wild Sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of 8.8 acres. About 0.6 acres will become established adjacent to the new channel.

(7) Aquatic Resources - Small sections of South Gabouri Creek, Gabouri Creek and the Mississippi Slough will be filled during levee construction. All water-dependent species within the affected reach will be destroyed or displaced by levee construction. There will no longer be connections between these water bodies and the Mississippi River during flood periods when water will be pumped. However, gravity drains will provide access to the Mississippi during low flow periods.

(8) Terrestrial (Wildlife) Resources - TABLE F-12 shows changes in habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard, blue-winged teal, great blue heron, common egret, and muskrat, as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure should have little or no effect on aesthetics since the levee will not be visible from the main part of the historic section of town.

(10) Sewage Treatment Plant - NSI

(11) Water Wells - Flood protection provided.

b. <u>Measure 10</u>

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. 89.3 acres will be removed from production.

(2) Wetlands - The borrow areas will become semi-permanently flooded, fresh water, emergent wetlands. The net effect will be an increase of 93 acres.

(3) Groundwater - NSI

(4) Water Quality - Protects water supply wells from flooding.

(5) Endangered Species

(a) Federal

1. Bald Eagle - NSI

2. Indiana Bat - 630 feet of Gabouri Creek and 850 feet of the Mississippi Slough will be eliminated which is potential Indiana bat summer habitat. The 1200 feet of Valle Spring Branch is not forested and therefore not potential Indiana bat summer habitat. A new 2660 feet channel will be established. The easement adjacent to the new channel will be allowed to grow into riparian forest which should take 15 to 20 years. The net effect will be a minor increase (1180 feet) of potential Indiana bat summer habitat.

3. State -It is unlikely that any species listed in the disturbed urban area and intensively farmed land will be impacted by this measure. Two species of plants, Primrose Willow and Wild Sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of 4.5 acres. About 1.2 acres will become established adjacent to the new channel.

(7) Aquatic Resources - Small sections of Gabouri Creek and the Mississippi Slough will be filled during levee construction. All water-dependent species within the affected reach will be destroyed or displaced by levee construction. Valle Spring Branch will be rerouted

into a new channel and sections of the stream will be filled for levee construction. There will no longer be connections between these water bodies and the Mississippi River during flood periods when water will be pumped. However, gravity drains will provide access to the Mississippi during low flow periods.

(8) Terrestrial (Wildlife) Resources - TABLE F-12 shows changes in habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard, blue winged teal, great blue heron, common egret, and muskrat, as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure should have little or no effect on aesthetics since the levee will not be visible from the main part of the historic section of town.

(10) Sewage Treatment Plant - NSI

(11) Water Wells - Flood protection provided.

c. Measure 11.

(1) Prime Farmland - Prime farmland will be removed by the building of levees and borrow areas for obtaining levee material. 89.7 acres will be removed from production.

(2) Wetlands - The borrow areas will become semi-permanently flooded, fresh water, emergent wetlands. The net effect will be an increase of 108 acres.

(3) Groundwater - NSI

(4) Water Quality - Protects water supply wells from flooding.

(5) Endangered Species

(a) Federal

1. Bald Eagle - NSI

2. Indiana Bat - 700 feet of Gabouri Creek and 870 feet of the Mississippi Slough will be eliminated which is potential Indiana bat summer habitat. No new channels will be established. The net effect is a minor decrease (1570 feet) of potential Indiana bat summer habitat.

3. State - It is unlikely that any species listed in the disturbed urban area and intensively farmed land will be impacted by this measure. Two species of plants, Primrose Willow and Wild Sweet William, may occur in the Mississippi Slough which will be cut through by the levee; however, the creation of borrow pit wetlands should more than compensate for this small loss.

(6) Floodplain Forest - This measure will result in the clearing of 4.5 acres.

(7) Aquatic Resources - Small sections of Gabouri Creek and the Mississippi Slough will be filled during levee construction. All water-dependent species within the affected reach will be destroyed or displaced by levee construction. There will no longer be connections between these water bodies and the Mississippi River during flood periods when water will be pumped. However, gravity drains will provide access to the Mississippi during low flow periods. Approximately 700 feet of lower Gabouri Creek will be diverted into a new channel.

(8) Terrestrial (Wildlife) Resources - TABLE F-12 shows changes in habitat types with this measure. The creation of wetlands will create good habitat for a variety of species such as the mallard, blue-winged teal, great blue heron, common egret, muskrat, as well as a variety of aquatic reptiles and amphibians.

(9) Aesthetics - This measure should have little or no effect on aesthetics since the levee will not be visible from the main part of the historic section of town.

(10) Sewage Treatment Plant - Flood protection provided.

(11) Water Wells - Flood protection provided.

d. Measure 12

(1) Prime Farmland - NSI

(2) Wetlands - NSI

(3) Groundwater - NSI

(4) Water Quality - Temporary increase in turbidity during construction and until bank vegetation becomes reestablished which should take no more than 6 months.

(5) Endangered Species

(a) Federal

1. Bald Eagle - NSI

2. Indiana bat - 2857 feet of South Gabouri Creek would be eliminated as potential Indiana bat summer habitat by removing riparian vegetation. The degraded water quality caused by mine waste discharges as well as the urban nature of this stream make it unlikely that it is important Indiana bat summer habitat.

3. State Species - It is unlikely that any of these sensitive species would occur in or adjacent to this disturbed, urban stream.

(b) Floodplain Forest - The riparian forest along 1.23 miles of the creek, on one side, will be replaced by mowed grass. Approximately 40 feet of a 50-foot right-of-way on the side of the creek that is widened, will be left in a natural state or planted in wildlife-preferred vegetation.

(7) Aquatic Resources - 1.23 miles of South Gabouri Creek will be widened to 30 feet bottom width with 1 vertical or 2 horizontal side slopes. The widening will take place from one side. The other side will be strengthened with gabions. The aquatic habitat will be degraded by the removal of trees. An important direct effect of the removal of riparian vegetation is the disruption of aquatic food webs and the reduction in invertebrate and fish production as a result of the loss of terrestrial energy inputs. Areas lacking deciduous vegetation commonly have low diversity and numbers of aquatic intervebrates. The loss of riparian vegetation can also increase water temperatures due to the loss of shade. A shift in community structure can occur with resident species being replaced by species more tolerant of increased temperatures. This measure is considered to have moderate adverse aquatic impacts.

(8) Terrestrial (Wildlife) Resources - The decrease in diversity of vegetative from riparian forest to mowed grass will have an

adverse impact. However, the impact will not be significant since the area impacted is relatively small and the existing habitat has been and is subject to disturbance being in a urban setting. A 50 foot right-of-way on the side of the creek to be widened of which approximately 40 feet will be left in a natural state or planted in wildlife preferred vegetation will help offset the loss of the riparian forest.

(9) Aesthetics - There should be a net positive impact due to the removal of man-made debris from the stream.

(10) Sewage Treatment Plant - NSI

(11) Water Wells - NSI

e. Measure 13

(1) Prime Farmland - NSI

(2) Wetlands - NSI

(3) Groundwater - NSI

(4) Water Quality - Temporary increase in turbidity during construction and until bank vegetation becomes reestablished which should take no more than 6 months.

(5) Endangered Species

(a) Federal

1. Bald Eagle - NSI

2. Indiana bat - 2059 feet of North Gabouri Creek would be eliminated as potential summer habitat by removing riparian vegetation. The disturbed nature of the riparian forest and the urban setting of the creek make it unlikely that it is important Indiana bat summer habitat.

3. State Species - It is unlikely that any of these sensitive species would occur in or adjacent to this disturbed urban stream.

(6) Floodplain Forest. The riparian forest along 0.60 miles of the creek, on one side, will be replaced by mowed grass. Approximately 40 feet of a 50-foot right-of-way on the side of the creek that is widened will be left in a natural state or planted in wildlife-preferred vegetation.

(7) Aquatic Resources - 0.60 miles of North Gabouri Creek will be widened to 30 feet bottom width with 1 vertical or 2 horizontal side slopes. The widening will take place from one side. The aquatic habitat will be degraded by the removal of shade. An important direct effect of

the removal of riparian vegetation is the disruption of aquatic food webs and the reduction in invertebrate and fish production as a result of the loss of terrestrial energy inputs. Areas lacking deciduous vegetation commonly have low diversity and numbers of aquatic intervebrates. The loss of riparian vegetation can also increase water temperatures due to the loss of shade. A shift in community structure can occur with resident species being replaced by species more tolerant of increased temperatures. This measure is considered to have a moderate adverse aquatic impact.

(8) Terrestrial (Wildlife) Resources - The decrease in diversity of vegetative from riparian forest to mowed grass will have an adverse impact. However, the impact will not be significant since the area impacted is relatively small and the existing habitat has been and is subject to disturbance being in a urban setting. A 50-foot right-of-way on the side of the creek to be widened, of which approximately 40 feet will be left in a natural state or planted in wildlife-preferred vegetation, will help offset the loss of riparian forest.

(9) Aesthetics - There should be a net positive impact due to the removal of man-made debris from the stream.

(10) Sewage Treatment Plant - NSI

(11) Water Wells - NSI

f. Measure 16. This measure, consisting of bike/foot trails along the widened portions of North and South Gabouri Creek and on top of Mississippi river levees, will have no significant impacts on any of the significant resources.

g. Measure 18.

(1) Prime Farmland - NSI

(2) Wetland - NSI

(3) Groundwater - NSI

(4) Water Quality - Temporary increase in turbidity during construction.

(5) Endangered Species

(a) Federal

1. Bald Eagle - NSI

2. Indiana bat - 2112 feet of stream channel would be reduced in value as potential Indiana bat summer habitat by removing trees that overhang the bank. The degraded water quality of this stream

as well as its urban nature, make it unlikely that it is important Indiana bat summer habitat.

3. State Species - It is unlikely that any of these sensitive species would occur in or adjacent to this disturbed urban stream.

(6) Floodplain Forest - There will be very little clearing of trees since only trees growing within the stream bank will be removed.

(7) Aquatic Resources - About 0.40 miles of North Gabouri Creek will be cleared and snagged which involves removing the man-made and natural debris in the stream channel as well as removing any trees growing within the stream banks. This will adversely impact the aquatic resources by removing the debris which is used by fish for cover and as substrate for aquatic invertebrates. The aquatic habitat will also be degraded by the removal of trees. An important direct effect of the removal of riparian vegetation is the disruption of aquatic food webs and the reduction in invertebrate and fish production as a result of the loss of terrestrial energy inputs. The loss of riparian vegetation can also increase water temperatures due to the loss of shade. A shift in community structure can occur with resident species being replaced by species more tolerant of increased temperatures. The impacts, on a whole are minimal due to the small length of creek affected.

(8) Terrestrial (Wildlife) Resources - This measure will have minimum impact on terrestrial resources due to its limited size. Terrestrial species that would use the stream such as muskrats, green herons, aquatic reptiles and amphibians will be adversely impacted by the decrease in habitat diversity.

(9) Aesthetics - There should be a net positive impact due to the removal of man-made debris from the stream.

(10) Sewage Treatment Plant - NSI

(11) Water Wells - NSI

h. <u>Measure 19</u>

(1) Prime Farmland - NSI

(2) Wetlands - NSI

(3) Groundwater - NSI

(4) Water Quality -Temporary increase in turbidity during construction.

(5) Enc..ngered Species

(a) Federal

1. Bald Eagle - NSI

2. Indiana bat - 2270 feet of stream channel would be reduced in value as potential Indiana bat summer habitat by removing trees that overhang the bank. The degraded water quality of this stream as well as its urban nature, make it unlikely that it is important Indiana bat summer habitat.

3. State Species - It is unlikely that any of these sensitive species would occur in or adjacent to this disturbed urban stream.

(6) Floodplain Forest - There will be very little cearing of trees since only trees growing within the stream bank will be removed.

(7) Aquatic Resources - About 0.43 miles of South Gabouri Creek will be cleared and snagged which involves removing the man-made and natural debris in the stream channel as well as removing any trees growing within the stream banks. This will adversely impact the aquatic resources by removing the debris which is used by fish for cover and as substrate for aquatic invertebrates. The aquatic habitat will also be degraded by the removal of trees. An important direct effect of the removal of riparian vegetation is the disruption of aquatic food webs and the reduction in invertebrate and fish production as a result of the loss

of terrestrial energy inputs. The loss of riparian vegetation can also increase water temperatures due to the loss of shade. A shift in community structure can occur with resident species being replaced by species more tolerant of increased temperatures. The impacts, on a whole are minimal due to the small length of creek affected. It is noted that South Gabouri Creek receives limestone mining wastes and the aquatic habitat is of lesser quality than North Gabouri Creek.

(8) Terrestrial (Wildlife) Resources - This measure will have minimum impact on terrestrial resources due to its limited size. Terrestrial species that would use the stream such as muskrats, green herons, aquatic reptiles and amphibians will be adversely impacted by the decrease in habitat diversity.

(9) Aesthetics - There should be a net positive impact due to the removal of man-made debris from the stream.

(10) Sewage Treatment Plant - NSI

(11) Water Wells - NSI

i. Measure 22.

(1) Prime Farmland - NSI

(2) Wetlands - NSI

(3) Groundwater - NSI

(4) Water Quality - NSI

(5) Endangered Species - NSI

(6) Flood plain Forest - NSI

(7) Aquatic Resources - NSI

(8) Terrestrial (Wildlife) Resources - There will be minor beneficial impacts where structures are removed and natural vegetation is restored.

(9) Aesthetics - This measure will have a moderately beneficial impact by removing structures that are subject to flooding and are often in need of upkeep.

(10) Sewage Treatment Plant - NSI

(11) Water Treatment Plant - NSI

7.2 MONETARY EVALUATION

TABLE F-13 displays the monetary gains and losses for Measures 9, 10 and 11. The major land use change is from open land to marsh type habitat. See TABLE F-5 for the calculations of the monetary value of these habitats. The change in monetary wildlife values for the other second iteration measures as well as change in fishery values are not considered to be significant.

TABLE F-13 Monetary Wildlife Values for Measures 9, 10, 11

Measure	Net Habitat Change				
	Openland		Marsh		Total
	Acres	$	Acres	$	$
9	-74.0	-$33	+ 79	+ $9,049	+ $9,016
10	-86.6	- 38	+ 93	+ 10,652	+ 10,614
11	-97.6	- 43	+ 108	+ 12,370	+ 12,327

7.3 IMPACT APPRAISAL

The impacts of each alternative for each significant ecological resource was evaluated using a numerical scale:

+3 - Major beneficial impact

+2 - Moderate beneficial impact

+1 - Minor beneficial impact

0 - No significant impact

-1 - Minor adverse impact

-2 - Moderate adverse impact

-3 - Major adverse impact

The severity of the impact was estimated using any quantitative data available (i.e., number of acres) as well as professional judgment.

The scores of each significant resource for each alternative were then added together and divided by the number of significant resources evaluated to give an average impact score. These are displayed in TABLE F-14.

TABLE F-14 - IMPACT APPRAISAL - SECOND ITERATION

Ecological Resources	Measures 9	10	11	12	13	16	18	19	22
Prime Farmland	+1	+1	+1	0	0	0	0	0	0
Wetlands	+1	+1	+2	0	0	0	0	0	0
Groundwater	0	0	0	0	0	0	0	0	0
Water Quality	0	0	0	-1	-1	0	0	0	0
Endangered Species	-1	+1	+1	-1	-1	0	-1	-1	0
Flood Plain Forest	-1	-1	-1	-1	-1	0	-1	-1	0
Aquatic Resources	-1	-1	-1	-2	-2	0	-1	-1	0
Terrestrial Resources	+2	+2	+2	-1	-1	0	-1	-1	+1
Aesthetics	0	0	0	+1	+1	0	+1	+1	+1
Sewage Lagoons	0	0	+3	0	0	0	0	0	0
Water Wells	+3	+3	+3	0	0	0	0	0	0
Average	0	+1	+1	0	0	0	0	0	0

SECTION 8 - EFFECTS OF FINAL PLANS ON ECOLOGICAL RESOURCES

8.1 IMPACT ASSESSMENT

Each plan that has been formulated is a combination of second iteration measures which have been assessed in the preceding section. Each plan is fully described in the Main Report and Appendix A, Plan Formulation.

TABLE F-15 summerizes the ecological impacts for each plan on each significant resource.

8.2 IMPACT APPRAISAL

The impacts of each alternative for each significant ecological resource where evaluated using a numerical scale

+3 - Major beneficial impact

+2 - Moderate beneficial impact

+1 - Minor beneficial impact

0 - No significant impact

-1 - Minor adverse impact

-2 - Moderate adverse impact

-3 - Major adverse impact

TABLE F-15

IMPACT ASSESSMENT OF FINAL PLANS ON SIGNIFICANT ECOLOGICAL RESOURCES

Ecological Resource	Plan 1	Plan 2	Plan 3	Plan 4	No Action
Prime Farmland	Loss of 76.0 ac. Protection of 385 ac.	Loss of 89.3 ac. 421 acres protected	Loss of 89.7 ac. 575 ac. protected	NSI	Continued periodic flooding 595 acres
Wetlands	Increase of 79 acres	Increase of 93 acres	In rease of 108 acres	NSI	NSI
Groundwater	NSI	NSI	NSI	NSI	NSI
Water Quality	Minor, temporary decrease	Minor, temporary decrease	Minor, temporary decrease	Minor,Temporary decrease	Continued degradation of South Gabouri Creek from lime mine discharges.
Endangered Species	Loss of 6255 feet of low quality potential Indiana bat summer habitat. Minor increase for 2 state listed plants.	Loss of 3736 feet of low quality potential Indiana bat summer habitat. Minor increase for 2 state listed plants.	Loss of 3346 feet of low quality potential *Indiana* bat summer habitat. Minorincrease for 2 state listed plants.	degradation of 4382 feet of low quality potential Indiana bat Summer habitat.	NSI
Floodplain Forest	Minor decrease	NSI	Minor decrease	NSI	NSI
Aquatic Resources	1.83 miles of tributary streams degraded	1.83 miles of tributary streams degraded	1.83 miles of tributary stream degraded	0.83 miles of tributary streams degraded.	NSI
Terrestrial Resources	Moderate beneficial impact for wetland species; minor loss of riparian habitat (6255 feet).	Moderate beneficial impact for wetland species; minor loss of riparian habitat (3736 feet).	Moderate beneficial impact for wetland species; minor loss of riparian habitat (3346 feet)	NSI	NSI

TABLE F-15 (Cont'd)

IMPACT ASSESSMENT OF FINAL PLANS ON SIGNIFICANT ECOLOGICAL RESOURCES

Ecological Resource	Plan 1	Plan 2	Plan 3	Plan 4	No Action
Aesthetics	Improvement because flood fight no longer necessary, buildings not damaged, neighborhood renewal.	Improvement because flood fight no longer necessary, buildings not damaged, neighborhood renewal.	Improvement because flood fight no longer necessary, buildings not damaged, neighborhood renewal.	NSI	NSI
Sewage Lagoons	NSI	NSI	Flood protection provided.	NSI	NSI
Water Wells	Flood protection provided.	Flood protection provided.	Flood protection provided.	NSI	NSI

The severity of the impact was estimated using any quantitative data available (i.e., number of acres) as well as professional judgment.

The scores of each significant resource for each alternative were then added together and divided by the number of significant resources evaluated to give an average impact score. These are displayed in TABLE F-16.

8.3 ECOLOGICAL RESOURCE OBJECTIVE FULFILLMENT

The amount of fulfillment of obtaining the ecological resource objectives is discussed for each plan. The results are summerized in TABLE F-17.

Plan 1

a. Enhance fish and wildlife habitat where there is an opportunity. This objective is partially achieved. The borrow pits will become marsh habitat and right-of-way adjacent to new and widened stream channels will revert to natural, forested conditions. However, riparian habitat would be lost adjacent to widened streams and the aquatic habitat would be degraded.

b. Avoid significant adverse impacts to endangered species. This objective has been achieved. Even though some potential Indiana bat summer habitat will be destroyed, it is not good quality and is not significant.

TABLE F-16

IMPACT APPRAISAL
FINAL PLANS

Ecological Resource	PLANS 1	2		4	No Action
Prime Farmland	+1	+1	+1	0	-1
Wetlands	+1	+1	2	0	0
Groundwater	0	0	0	0	0
Water Quality	-1	-1	-1	-1	0
Endangered Species	-1	-1	-1	-1	0
Flood Plain Forest	-1	-1	-1	0	0
Aquatic Resources	-2	-2	-2	-1	0
Terrestrial Resources	+1	+1	+1	0	0
Aesthetics	+1	+1	+1	0	+2
Sewage Lagoons	0	0	+3	0	0
Water Wells	+3	+3	+3	0	0
Average	0	0	+1	0	0

TABLE 17

ECOLOGICAL RESOURCE OBJECTIVE FULFILLMENT
FINAL PLANS

Ecological Resource Objective	PLANS 1	2	3	4	No Action
1. Enhance fish and wildlife habitat where there is an opportunity.	P	P	P	N	N
2. Avoid significant adverse impacts to endangered species.	F	F	F	F	F
3. Enhance and increase wetlands when practical.	F	F	F	N	N
4. Protect prime farmland from flooding.	F	F	F	N	N

Key: F - Objective achieved.
P - Objective partially achieved.
N - Objective not achieved.

c. Enhance and create wetlands when practical. This objective has been achieved by creating 79 acres of marsh from borrow pits.

d. Protect prime farmland from flooding. This objective has been achieved. Although 76.0 acres of prime farmland will be destroyed by the levee, 385 acres, most of which is not presently prime farmland because of frequent flooding, will become prime farmland by being protected from flooding.

PLAN 2

a. Enhance fish and wildlife habitat where there is an opportunity. This objective is partially achieved. The borrow pits will become marsh habitat and right-of-way adjacent to new and widened stream channels will revert to natural, forested conditions. However, riparian habitat would be lost adjacent to widened streams and the aquatic habitat would be degraded.

b. Avoid significant adverse impacts to endangered species. This objective has been achieved. Even though some potential Indiana bat summer habitat will be destroyed, it is not good quality and is not significant.

c. Enhance and create wetlands where practical. THis objective has been achieved by creating 93 acres of marsh from borrow pits.

d. Protect prime farmland from flooding. This objective has been achieved. Although 89.3 acres of prime farmland will be destroyed by the levee, 421 acres, most of which is not presently prime farmland because of frequent flooding, will become prime farmland by being protected from flooding.

Plan 3

a. Enhance fish and wildlife habitat where there is an opportunity. This objective is partially achieved. The borrow pits will become marsh habitat and right-of-way adjacent to new and widened stream channels will revert to natural, forested conditions. However, riparian habitat would be lost adjacent to widened streams and the aquatic habitat would be degraded.

b. Avoid significant adverse impacts to endangered species. This objective has been achieved. Even though some potential Indiana bat summer habitat will be destroyed, it is not good quality and is not significant.

c. Enhance and create wetlands when practical. This objective has been achieved by creating 108 acres of marsh from borrow pits.

d. Protect prime farmland from flooding. This objective has been achieved. Although 89.7 acres of prime farmland will be destroyed by the levee, 575 acres, most of which is not presently prime farmland because

of frequent flooding, will become prime farmland by being protected from flooding.

Plan 4

a. Enhance fish and wildlife habitat where there is an opportunity. This objective has not been achieved.

b. Avoid significant adverse impacts to endangered species. This objective has been achieved. Even though some potential Indiana bat summer habitat has been degraded, it is not good quality and not significant.

c. Enhance and create wetlands when practical. This objective has not been achieved.

d. Protect prime farmland from flooding. This objective has not been achieved.

No Action

a. Enhance fish and wildlife habitat where there is an opportunity. This objective has not been achieved.

b. Avoid significant adverse impacts to endangered species. This objective is achieved.

c. Enhance or create wetlands where practical. This objective is not achieved. No wetlands are created.

d. Protect prime farmland from flooding. This objective is not achieved. Flooding will continue.

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FEASIBILITY REPORT

APPENDIX G

RECREATION

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RECREATION

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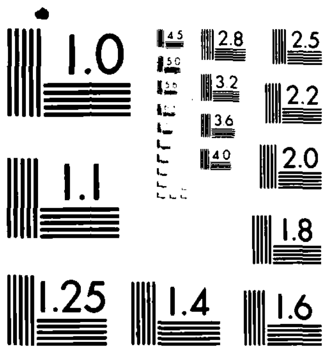
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

SECTION 2 - RECREATION DEMAND

The population of the City of Ste. Genevieve and Ste. Genevieve County is as follows:

Ste. Genevieve City	Ste. Genevieve County
1970 - 4,468	12,867
1980 - 4,481	15,180

The population of the city is reasonably served by the existing park acres. The parks are grouped to the north of the city. The city is especially interested in the developments of trails, picnic areas and baseball fields.

2.1 RECREATION MARKET

Before developing the recreation unmet needs for the community the recreation market was established.

The people of Ste. Genevieve County divide equally and go to Farmington and Ste. Genevieve for their principal recreation activities. Therefore, the recreation market for this study has been established as one half of the population of Ste. Genevieve County. Visitors to the city for the historic features are numerous (30,000 in 1981) therefore, 10 percent of the county's population is added to the recreation market to account for the visitors who use the recreation features of the city.

One Half of County Population	=	7,590
Visitor Use	=	1,518
Recreation Market Base Population		9,108

SECTION 3 - FUTURE RECREATIONAL RESOURCES WITHOUT CORPS PROJECT

The Comprehensive Plan (1978) for the City of Ste. Genevieve shows a future interest in acquiring and developing parks in a linear fashion up North and South Gabouri Creeks and Valle Spring Branch. Neighborhood parks are spread throughout the city. The plan recommends the development of small parks at the St. Jude subdivision and the Point Basse area. No timetable has been set or money appropriated for these goals.

SECTION 4 - RECREATION OPPORTUNITIES

Comparison of existing and planned recreation facilities with the projected demand for recreation showed that there are unmet needs for the following types of facilities; picnicking, softball, tot lots, disc golf course, exercise trail, open play areas, hiking trails, and bicycling trails.

SECTION 5 - RECREATION OBJECTIVE

One objective of the Corps of Engineers planning effort is to increase the quality and quantity of recreation opportunities within the study area.

SECTION 6 - FIRST ITERATION

As part of the Corps of Engineers' first planning iteration a maximum recreation measure called Measure 15 was developed. The measure could be selectively adopted to flood damage reduction plans developed later in the study. Measure 15 included land along North Gabouri Creek, one parcel of land adjacent to South Gabouri Creek, trails on major levees and along tributary streams, facilities for group recreation activities, and use of borrow areas for nature study.

In the first iteration, recreation was formulated under Principals and Standards. The recreation value used was $1.00/visitor day. The total first cost for Measure 15 was $541,000. Annual costs were $48,000 and annual benefits were $57,000, and the benefit/cost ratio was 1.17.

SECTION 7 - SECOND ITERATION

7.1 RECREATION POINTS

Before evaluating recreation opportunities associated with the selected flood control plan, points for general recreation were evaluated as directed by the <u>Economic & Environmental Principles & Guidelines for Water and Related Land Resources Implementation Studies.</u> Based on

knowledge of the quality of the existing recreation facilities in the study area and comparing with other local recreation developments the point assignment was selected as follows:

Criteria	Judgement Factors	Total Possible Points	Selected Points
Recreation Experience	Several general activities.	30	7
Availability of Opportunity	Several within 1 hour, few within 30 min.	18	3
Carrying Capacity	Basic facilities for activities.	14	3
Accessibility	Fair access, fair roads to site, good existing roads at park.	18	7
Environmental Quality	Above average aesthetic quality, limiting factors can be improved.	20	10*
	TOTALS	100	30

*The historic architectural fabric is unique.

The conversion of total points to dollar values is displayed on TABLE VIII-3-1 of Economic & Environmental Principals & Guidelines dated March 10, 1983. The conversion resulted in a $2.40 value for a recreation visitor occasion.

7.2 RECREATION PLAN

Measure 16 is the recreation measure developed in the second iteration of the Corps of Engineers' study and formulated to go with

Plan 1 (Measures 9, 12, & 13). All recreation features occur on flood control lands. Measure 16 is shown on PLATE A-17 in VOLUME THREE of this report.

7.2.1 Measure 9 provides a levee that proceeds from Valle Spring Branch to the sewage lagoon and then to high ground north of Pere Marquette Park. A recreational trial for hiking and bicycling on the levee would be 2.65 miles long.

7.2.2 Measure 12 provides for channel widening on South Gabouri Creek. The hiking and bicycling trail along South Gabouri Creek is 0.94 miles long. The trail begins at Front Street (Left Bank) where there is proposed parking for 8 cars, 5 picnic tables, and 1 bike rack. Continuing on the left bank the trail crosses Main Street and continues to Fourth Street. Crossing would be at the existing bridge and the trail would continue on the right bank. At Sixth Street land would be available for 5 picnic tables and a softball field. The trail would terminate at Tenth Street.

7.2.3 Measure 13 provides for channel widening on North Gabouri Creek. The hiking and bicycling trail along this stream would be 0.61 miles long. At North Main Street, where there are 2 proposed picnic tables and a bike rack, the trail begins and then continues westerly on the left bank to Second Street. A foot bridge carries the trail to the right bank, and six picnic tables are proposed in this area. An exercise trail

is proposed between Second and Fourth Streets. A softball field is proposed above Third Street. Below Fourth Street a 20 car parking lot and a bike rack are proposed. At Fourth Street the existing bridge provides a crossing to the left bank and permits the trail to continue to its terminus near La Haye Street. At RM 1.8 a foot bridge is provided. This crossing will permit the local sponsor to extend the trail over their own easement to the school complexes. With this extension of the trail many students can travel to school with little or no traffic hazard.

7.3. RECREATION OBJECTIVE FULFILLMENT

The stated objective of the recreation component was to increase the quantity and quality of recreation opportunities within the study area. TABLE G-1 provides a summary of existing recreation facilities, a comparison of existing and proposed facilities, the unmet needs, and the visitor occasions that will be generated by Measure 16. Measure 16 would increase the visitor occasions in the study area by 18,837 and generate annual recreation benefits of $45,200. The total first cost of Measure 16 is $150,000 and its annual costs are $19,000. Measure 16 has a benefit/cost ratio of 2.4.

TABLE G-1

RECAREATION ANALYSIS FOR MEASURE 16

RECREATION FACILITIES	NUMBER OF FACILITIES AT EXISTING PARKS IN STE. GENEVIEVE				COMPARISON OF EXISTING & PROPOSED RECREATION FACILITIES					
	PERE MARQUETTE PARK	KHOURY LEAGUE FIELD	LIONS PARK	COUNTY BASEBALL PARK	MAXIMUM DESIRABLE FACILITIES	EXISTING FACILITIES	PRESENT UNMET NEEDS	FACILITIES IN MEASURE 16	REMAINING UNMET NEEDS	VISITOR OCCASIONS OF MEASURE 16
SOFTBALL (FIELDS)	1			1	5.6	2.0	3.6	2.0*	1.6	+6,600
BASEBALL (FIELDS)	1	2			5.6	3.0*	2.6	-1.0*	3.6 *	-3,300
PICNIC TABLES (TABLES)	14		3		112.0	17.0	95.0	18.0	77.0	+2,700
HIKING TRAILS (MILES)	0	0	0	0	15.0	0.0	15.0	4.2	10.8	+6,237
BICYCLING TRAIL (MILES)	0	0	0	0	9.0	0.0	9.0	4.2	4.8	+4,200
EXERCISE TRAIL (MILES)	0	0	0	0	3.0	0.0	3.0	1.0	2.0	+2,400

18,837 x $2.40 = $45,208

say $45,200

* One baseball field at the Khoury League Field will be destroyed by Plan 1. Space will allow replacement with a softball field.

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APPENDIX H

ECONOMIC ANALYSIS

SECTION 1 - INTRODUCTION

The purpose of this appendix is to present a summary of the detailed economic analysis accomplished for the Ste. Genevieve, Missouri Flood Control study. The study area is located in Ste. Genevieve County in southeastern Missouri, about 54 miles south of St. Louis. Ste. Genevieve is at the edge of the Mississippi River flood plain, on the right bank of the river between river miles 122 and 124 above the Ohio River. The study area includes the entire town of Ste. Genevieve, the Mississippi River flood plain lying east of the town, and the areas that drain into the community, including the watersheds of North Gabouri Creek, South Gabouri Creek, and Valle Spring Branch. The economic data herein are based on October 1982 price levels. Average annual computations are based on a 7-7/8 percent interest rate and a 100-year period of analysis.

SECTION 2 - SOCIOECONOMIC BASE AND PROJECTED CHARACTERISTICS

2.1 POPULATION

2.1.1 Base Numbers.

Historical population statistics for both Ste. Genevieve County and

City from 1900 to 1980 are shown in TABLE H-1. Ste. Genevieve County's statistics indicate that it has grown at an average rate of 5.1 percent per census period since 1900. The actual rate for any period did not exceed 8.0 percent until the period of 1970 to 1980 when an 18.0 percent rate was evidenced. The lowest actual rate occurred during the period from 1910 to 1920 when a 7.5 percent decrease in population was experienced. The total population of Ste. Genevieve County in 1980 was 15,180.

TABLE H-1
POPULATION TRENDS AND PROJECTIONS

	Ste. Genevieve County	Percent Change	City of Ste. Genevieve	Percent Change
1900	10,359		1,707	
1910	10,607	2.4	1,967	15.2
1920	9,809	-7.5	2,046	4.0
1930	10,097	2.9	2,662	30.1
1940	10,905	8.0	2,787	4.7
1950	11,237	3.0	3,992	43.2
1960	12,116	7.8	4,443	11.3
1970	12,867	6.2	4,468	0.6
1980	15,180	18.0	4,727	5.8*
1990	15,651	3.1	4,874	3.1
2000	16,011	2.3	4,986	2.3
2010	16,379	2.3	5,101	2.3
2020	16,756	2.3	5,218	2.3
2030	17,141	2.3	5,338	2.3

SOURCE: 1980 OBERS [NON-SMSA Part of BEA Economic Area 107: St. Louis, Missouri (Missouri Part)] and 1980 U.S. Census of Population and Housing.

*Largely due to 1972 annexation of St. Jude Acres Subdivision - Population 246.

The City of Ste. Genevieve, which is the largest city in the County, has experienced an average growth rate of 14.4 percent per census period from 1900 to 1980. The census period of 1960 to 1970 reflected the lowest rate of growth (0.6) since 1900. Prior to this, the rate had not been lower than 4.0 percent. The highest rates occurred during the periods 1920 to 1930 and 1940 to 1950 when growths of 30.1 and 43.2 percent took place. The total population for the City of Ste. Genevieve in 1980 was 4,727.

2.1.2 Projected Numbers.

The population projections for Ste. Genevieve County shown in TABLE H-1 are based on 1980 OBERS data for the NON-SMSA Part of Bureau of Economic Analysis (BEA) Economic Area 107: St. Louis, Missouri (Missouri Part). These projections reflect the assumption that there will be no change in the share of population retained within the area. Increases of 3.1 percent for the decade of 1980 to 1990 and 2.3 percent for each succeeding decade through the year 2030 are projected for this NON-SMSA Area. These rates differ considerably from not only the average historical rates, but also the most recent rates experienced by both Ste. Genevieve County and the City of Ste. Genevieve.

The projected rates used also differ from those used in the Ste. Genevieve, Missouri Comprehensive Plan, 1978, done by the Southeast Missouri Regional Planning and Economic Development Commission.

The Comprehensive Plan has projections for census periods through the year 2000. Its projected rate of growth for Ste. Genevieve County is a constant 10.2 percent for census periods ending in 1980, 1990, and 2000. Bureau of the Census information for 1980 indicates 10.2 percent as too low an estimate. The Comprehensive Plan's projected rate of growth for the same periods in the City of Ste. Genevieve are 8.9 percent, 9.8 percent, and 8.3 percent, respectively. Bureau of the Census 1980 data indicates 8.9 percent as too high an estimate.

Due to its close proximity to the St. Louis Standard Metropolitan Statistical Area (SMSA), and recent growth history, the rates of growth projected by OBERS data for the Ste. Genevieve County area may be low. Conversely, given the City's 1960-1970 low rate of growth, the fact that the 1970-1980 rate of 5.8 percent was largely due to the annexation of St. Jude Acres, and somewhat restricted directions in which the City can grow, using the County projected rates of OBERS for the City of Ste. Genevieve may be too high.

2.1.3 Base Characteristics.

Selected population characteristics are shown in TABLES H-2, H-3, H-4, and H-5. TABLE H-2 displays the 1970 and 1980 census breakdown of the population of the Ste. Genevieve County by age and sex. The population gender has remained closely split with females having increased their majority from a 0.2 percent greater to a 0.8 percent

greater share than males. The median age of females has risen from 28.6 years in 1970 to 31.0 years in 1980. Males over the same period have had a rise in median age from 26.5 to 28.4.

TABLE H 2
STE. GENEVIEVE COUNTY
POPULATION DISTRIBUTION
BY AGE AND SEX, 1970 & 1980

	1970						1980					
AGE	TOTAL	%	MALE	%	FEMALE	%	TOTAL	%	MALE	%	FEMALE	%
0-4	1,098	8.5	594	4.6	504	3.9	1,237	8.2	645	4.3	592	3.9
5-9	1,488	11.6	768	6.0	720	5.6	1,175	7.7	610	4.0	565	3.7
10-14	1,560	12.1	788	6.1	772	6.0	1,370	9.0	688	4.5	682	4.5
15-19	1,261	9.8	644	5.0	617	4.8	1,592	10.5	825	5.4	767	5.1
20-24	665	5.1	323	2.5	342	2.6	1,202	7.9	612	4.0	590	3.9
25-29	694	5.4	326	2.5	368	2.9	1,101	7.2	566	3.7	535	3.5
30-34	636	4.9	324	2.5	312	2.4	980	6.5	525	3.5	455	3.0
35-44	1,336	10.4	650	5.0	686	5.4	1,625	10.7	788	5.2	837	5.5
45-54	1,347	10.5	654	5.1	693	5.4	1,536	10.1	752	4.9	784	5.2
55-59	657	5.1	345	2.7	312	2.4	773	5.1	372	2.5	401	2.6
60-64	601	4.7	283	2.2	318	2.5	664	4.4	325	2.1	339	2.3
65-74	898	7.0	458	3.6	440	3.4	1,162	7.7	539	3.6	623	4.1
75 +	626	4.9	271	2.1	355	2.8	763	5.0	288	1.9	475	3.1
	12,867	100%	6,428	49.9%	6,439	50.1%	15,180	100%	7,535	49.6%	7,645	50.4%

SOURCE: 1980 U.S. Census of Population and Housing.

TABLE H-3
STE. GENEVIEVE COUNTY
1980 POPULATION BY RACE

Race	Number	Percent
White	15,091	99.4
Black	47	0.3
American Indian	20	0.1
Other	22	0.2
	15,180	100.0

SOURCE: 1980 U.S. Census of Population and Housing.

TABLE H-4
STE. GENEVIEVE COUNTY
SELECTED 1980 CENSUS DATA BY HOUSEHOLD TYPE AND RELATIONSHIP

	Total	Percent	65 yrs. and over
In Family Household:			
Householder	4,001	26.4	681
Spouse	3,617	23.8	400
Other Relatives	6,237	41.1	146
Non-Relatives	92	0.6	7
	13,947	91.9	1,234
In Non-Family Household:			
Male Householder	347	2.3	120
Female Householder	593	3.9	406
Non-Relatives	88	0.6	17
	1,028	6.8	543
In Group Quarters:			
Inmate of Institution	164	1.0	137
Other	41	0.3	11
	205	1.3	148
TOTALS	15,180	100.0	1,925

SOURCE: 1980 U.S. Census of Population and Housing.

The County population's racial structure is primarily white (99.4 percent) with the balance as shown in TABLE H-3. TABLE H-4 displays the living arrangements existing in Ste. Genevieve County as of 1980, and includes some age, sex, and inhabitant relationship information. The primary living arrangement is the family household with 91.9 percent of the population involved. Married individuals comprised 48.8 percent of the population with the majority of the remainder being both young and elderly relatives.

The educational level of those 25 years of age and over living in Ste. Genevieve County has experienced some fluctuation since 1960. The 1960 census recorded 41.9 percent of this age group as having a high school education compared to the 53.7 percent evidenced in 1970. Those having a college education decreased from 7.3 percent in 1960 to 6.4 percent in 1970. TABLE H-5 presents the number of individuals having completed varying levels of education by the 1980 Census. Those having completed high school dropped to 51.3 percent of the age group in contrast to the 1960 to 1970 increase. The college graduates in the age group continued to decline as the 6.2 percent for the 1980 Census reflects.

TABLE H-5
STE. GENEVIEVE COUNTY
PERSONS 25 YEARS OLD AND OVER BY YEARS OF SCHOOL COMPLETED IN 1980

	Number	Percent
Elementary (0 to 8 years)	3,061	35.6
High School (1 to 3 years)	1,130	13.1
High School (4 years)	3,329	38.7
College (1 to 3 years)	550	6.4
College (4 years)	534	6.2
Total	8,604	100.0

SOURCE: 1980 U.S. Census of Population and Housing.

2.1.4 Projected Characteristics.

It is not believed that the trends of the population characteristics of Ste. Genevieve County, and specifically the study area, will change significantly in the projected future. The gender makeup should continue to be close to evenly split, while the racial structure remains almost exclusively white. Family households are the likely primary living arrangements for the future.

The two characteristics most apt to change over time are the median age and educational level of the population. The median age is most likely going to continue to rise as the area's population ages and more than offsets new births. The other major influence on median age and the major cause for fluctuation of the educational level will be the number of individuals graduating from high school and college and remaining in the area. The current indications are that these individuals, upon entering the labor force, are going to have to consider relocating to other job markets. Should this occur, the median age would tend to increase while the educational level would tend to decrease. Other factors could help to negate these movements, i.e., graduates not entering the labor force, graduates being willing to live in the area and commute to another job market, an increase in the availability of local employment opportunities, and the possibility of current non-residents locating in the area.

2.2 Economy

2.2.1 Base.

Manufacturing, professional services, retail trade, agriculture, and construction are the five primary areas of employment in Ste. Genevieve County. TABLE H-6 displays the number of individuals employed in 1980 by industry. The figures in TABLE H-6 for the five primary areas mentioned above employ 34.2, 16.0, 13.9, 11.4, and 8.0 percent respectively of the County's workers. The other areas of employment employ the 16.5 percent remainder. Tourism, due to the historic nature of the City of Ste. Genevieve, influences several areas of employment. Likewise, agricultural endeavors are felt in numerous other areas.

TABLE H-6
STE. GENEVIEVE COUNTY
EMPLOYED PERSONS 16 YEARS AND OVER BY INDUSTRY

Industry	Employed Persons	Percent
Agriculture, Forestry, Fisheries, and Mining	718	11.4
Construction	501	8.0
Manufacturing	2,155	34.2
Transportation	257	4.1
Communications and Other Public Utilities	137	2.2
Wholesale Trade	112	1.8
Retail Trade	877	13.9
Finance, Insurance, and Real Estate	150	2.4
Business and Repair Services	76	1.2
Personal, Entertainment, and Recreation Services	142	2.3
Professional and Related Services	1,009	16.0
Public Administration	159	2.5
	6,293	100.0

SOURCE: 1980 U.S. Census of Population and Housing.

The unemployment rate for Ste. Genevieve County has risen from approximately 8.3 percent during the 1980 Census to 16.0 percent in February 1982. In February 1983 the rate had declined to 12.7 percent made up of 7.6 percent men and 5.1 percent women. Although this compares favorably to the 1982 rate, there are fewer individuals in the labor force today. These figures are shown in TABLE H-7.

TABLE H-7
STE. GENEVIEVE COUNTY
NUMBER AND RATE OF PEOPLE UNEMPLOYED

	Employed	Unemployed	Rate
1980	6,293	567	8.3%
1982	5,166	984	16.0%
1983	4,738	688	12.7%

SOURCE: 1980 U.S. Census of Population and Housing; and Missouri Division of Employment Security.

TABLE H-8 shows the number of families by income amounts as recorded during the 1980 Census. The figures indicate that approximately 12.0 percent of the families had incomes of less than $7,500 while 5.4 percent had incomes of $40,000 or more. Families having incomes less than the poverty level totalled 307 or 7.7 percent of all families.

TABLE H-8
STE. GENEVIEVE COUNTY
FAMILIES BY FAMILY INCOME

Income	Number of Families	Percent
Less than $2,500	86	2.2
$ 2,500 to $ 7,499	393	9.9
$ 7,500 to $14,999	995	25.0
$15,000 to $22,499	1,071	26.9
$22,500 to $29,999	795	20.0
$30,000 to $39,999	422	10.6
$40,000 to $74,999	205	5.1
$75,000 or more	11	.3
	3,978	100.0

SOURCE: 1980 U.S. Census of Population and Housing.

Nearly 12.0 percent of the families residing in Ste. Genevieve County had no workers in their family unit compared to 29.5 percent with one worker and 58.5 percent with 2 or more workers. TABLE H-9 displays 1980 Census figures used in arriving at these percentages.

TABLE H-9
STE. GENEVIEVE COUNTY
FAMILIES BY WORKERS IN FAMILY

Number of Workers Per Family	Number of Families	Percent
0	479	12.0
1	1,173	29.5
2 or more	2,326	58.5
	3,978	100.0

SOURCE: 1980 U.S. Census of Population and Housing.

Using the implicit GNP Price Deflator to adjust the $8,020 median family income recorded during the 1970 Census from 1970 to 1979 dollars, a 24.3 percent increase over the past decade, from $15,041 to the current $18,693, occurred. The median income recorded by the 1980 Census in 1979 for unrelated individuals in Ste. Genevieve County was $5,660, 66.4 percent over the 1970 median. Approximately 2.3 percent of these individuals made $25,000 or more while nearly 42.6 percent earned less than $5,000. TABLE H-10 shows the 1980 Census figures for individuals by income level.

TABLE H-10
STE. GENEVIEVE COUNTY
UNRELATED INDIVIDUAL INCOME

Income Level	Number of Individuals	Percent
Less than $4,999	473	42.6
$ 5,000 to $ 9,999	315	28.4
$10,000 to $14,999	230	20.7
$15,000 to $24,999	68	6.1
$25,000 or more	25	2.2
	1,111	100.0

SOURCE: 1980 U.S. Census of Population and Housing.

2.2.2 Projected

Professional services and retail trade, two of the five primary areas of employment in Ste. Genevieve County, are projected by OBERS to increase in total number of employees for each decade through the year 2030. The numbers of workers in manufacturing and construction are projected to increase through 1990 and 2000, respectively. Agricultural employment is expected to continue to fall. These changes, shown in TABLE H-11, reflect minor fluctuations in the total number of jobs available, however.

TABLE H-11
STE. GENEVIEVE COUNTY
EMPLOYMENT BY INDUSTRY

Industry	EMPLOYED PERSONS 1980	1990	2000	2010	2020	2030
Agricultural	718	613	543	504	465	426
Construction	501	559	569	569	568	567
Manufacturing	2,155	2,274	2,261	2,236	2,211	2,186
Transportation	257	279	282	279	276	273
Communications	137	146	144	143	139	137
Wholesale Trade	112	119	116	113	110	107
Retail Trade	877	1,008	1,051	1,055	1,059	1,063
Finance	150	182	191	193	195	197
Business	76	92	99	102	105	108
Personal Services	142	171	185	190	195	200
Professional Services	1,009	1,217	1,317	1,351	1,385	1,419
Public Admin.	159	171	174	174	174	174
TOTAL	6,293	6,831	6,932	6,909	6,882	6,857

SOURCE: 1980 OBERS NON-SMSA Part of BEA Economic AREA 107: St. Louis, Mo. (MO PART).

Once again using OBERS projections, median family income will continue to grow, as presented in TABLE H-12, approximating $55,232 in 2030. Median unrelated individual income, also displayed in TABLE H-12, should reach $16,723 by 2030.

TABLE H-12
STE. GENEVIEVE COUNTY
MEDIAN FAMILY AND UNRELATED INDIVIDUAL INCOME PROJECTIONS

	1980	1990	2000	2010	2020	2030
Family	$18,693	$23,404	$28,857	$37,649	$46,441	$55,232
Unrelated Individual	$ 5,660	$ 7,086	$ 8,737	$11,399	$14,061	$16,723

SOURCE: 1980 OBERS [NON-SMSA Part of BEA Economic AREA 107: St. Louis, Missouri (MISSOURI PART)].

Several factors will help determine the unemployment outlook for future years. Major factors include the availability of local employment opportunities, the willingness of the local labor force to commute to other job market areas, and the willingness of the labor force to relocate in order to find jobs elsewhere.

At this time Ste. Genevieve County's overall economic outlook is one of little change. The same can be said for the City of Ste. Genevieve. The city may experience minor growth, however, it is somewhat restricted in that expansion at this time is limited except to the west. Frequent flooding has made it increasingly difficult to improve the area, especially the historic region, and maximize the existing tourism opportunities. Many in the labor force must leave the area to find work with little indication that the job market will change significantly in the future.

SECTION 3 - FLOOD DAMAGE ANALYSIS

3.1 FLOOD DAMAGE CALCULATION PROCEDURES

Placing a dollar value on historic worth is an elusive problem - one plagued by conceptual and philosophical issues which impact on how one reflects the intrinsic nature of what history is worth to society. Many of the homes and buildings located in Ste. Genevieve are of national historic significance and are periodically flooded. The values used to evaluate flood damages and benefits were based upon the traditional valuation techniques used by appraisers, i.e., market comparables. This approach misses the historic significance (historic worth) of these properties. A paper entitled "A PROPOSED METHOD OF EVALUATING FLOOD DAMAGES TO HISTORIC HOMES - AN EXTERNALITY APPROACH" suggested a different approach to valuing historic structures.[1] The technique relied upon a "replication value" rather than market value. Briefly, this paper advocates that a historic home's value is best represented by what it would cost to rebuild that historic home today, but using the same skills and building materials as those used in its original construction. Construction would then involve using wooden pegs, handcut timber beams, mortar made from clays, original architectural style, etc.

[1] Rodakowski, Richard, "A PROPOSED METHOD OF EVALUATING DAMAGES TO HISTORIC HOMES - AN EXTERNALITY APPROACH." Water Resources Bulletin, Vol. 14, No 6. (December 1978): 1295-1303.

The effort would capture the labor cost of older techniques, trades, and skills foregone by decades of technological change. A structure's intrinsic value (historic worth) would then be much greater. Annual flood damages and benefits would also be greater.

While this technique of valuing historic structures may have merit, the District believes the technique substantially underestimates the true value of historic homes. The District believes no price can adequately reflect historic worth. Consequently, the application of this technique to the Ste. Genevieve study was abandoned in favor of traditional procedures with the caveat that what is being measured does not capture any of the historical value of these homes.

HEC-1 hydrologic (frequency-discharge) output and HEC-2 hydraulic (stage-discharge) output were used in conjunction with basic economic stage-damage information to estimate the dollar amount of flood damages expected to occur on an average annual basis within the Ste. Genevieve study area. The procedure used to compute average annual damages involved: locating all flood damageable properties; estimating their structural, content, and associated miscellaneous damages; computing total damages per flood event; and finally, computing average annual damages. Each of the above steps were followed for existing, future-without, and future-with project conditions for a number of structural and non-structural flood control measures and alternative plans. Agricultural damages in the flood plain adjacent to the city of Ste. Genevieve were also included in the analysis. A discussion of these

damages will follow that of residential and commercial considerations. The procedure for residential and commercial computations makes use of a St. Louis District computer program entitled "Urban Damage II." Some of the discussion which follows relates to that program's development, and is not necessarily specific to the Ste. Genevieve study area. It is presented, however, to provide an understanding of program operations. References to some of the interviews, inquiries, and surveys pursued by District personnel in the development of depth-damage percentage relationships used in the computations were not always performed in the Ste. Genevieve area. Phone interviews and personal visits to Ste. Genevieve and vicinity, however, assisted in the determination and assignment of specific developed damage code types to those structures inventoried in the study area.

3.1.1 Locating Damageable Property

The process of determining average annual damages began with field surveys of all residential, commercial, and industrial property located within the standard project flood plain boundaries of the entire study area as defined by hydraulic studies. (See APPENDIX C.) The Ste. Genevieve study area was divided into four areas, designated as Areas I, II, III and 500, for the purposes of this analysis. See FIGURE H-1. Area I is the area within the city limits south of South Gabouri Creek. Area II is the area within the city limits between North

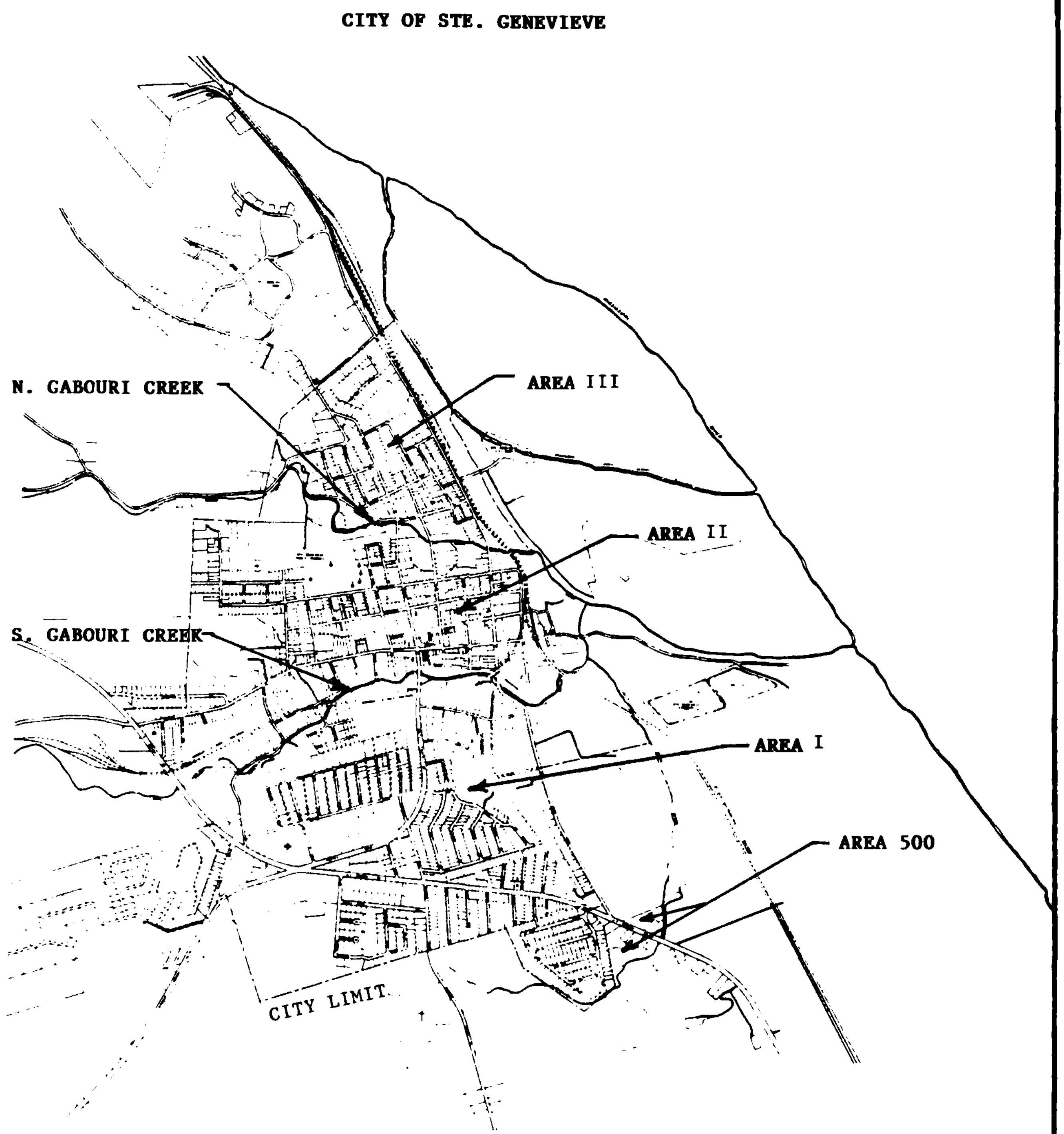
CITY OF STE. GENEVIEVE
N. GABOURI CREEK
AREA III
AREA II
S. GABOURI CREEK
AREA I
AREA 500
CITY LIMIT

FIGURE H-1

and South Gabouri Creeks. Area III is the area north of North Gabouri Creek and includes some structures that are outside the city limits. Area 500 is a small commercial area outside the city limit lying along US highway 61. Areas I, II and III are divided naturally by the two Gabouri Creeks which flow through the town. Area 500 was considered separately because it was not located within the city limits, contained a significant number of structures that flooded, and several measures considered during the study would exclude it from any protection.

Each structure in the four areas was inventoried and cataloged according to location, first floor elevation, type of structure (commercial or residential), value of structure, structure damage type, and river mile location along the stream creating the flood hazard, i.e., Mississippi River, North Gabouri or South Gabouri Creek. The first floor elevations were determined for the most part by survey instrument.

3.1.2 Estimating Depth Damage Values.

Total damages are the sum of the structural damage, the content damage, and miscellaneous damages associated with each structure type and use. Structural damages are normally computed by multiplying a structure value by a specific percentage of damage, the value of which varies with the depth of water in the structure. Content damages are computed by multiplying a content value by a similar percentage related to depth of

water. Miscellaneous damages attempt to account for items associated with household and community infrastructure flood damages that are not covered in a structure or content computation. Procedures used to compute both residential and commercial/industrial damages are discussed below.

3.1.3 Residential Damage Curves.

Structural and content damages to residential structures were computed by relating 1974 Federal Insurance Administration (FIA) depth-damage percentage curves for each structure damage type to the water surface frequency profile elevations (depth above or below the first floor elevation) at each structure inventoried within the Standard Project Flood (SPF) flood plain.

A survey of insurance companies specializing in home-owner policies and the State of Missouri Office of Insurance indicated the value of the contents of a residential unit in an urban area is normally estimated to be 50 percent of the structural value. This content value, therefore, was used with the content depth-damage percentages given in the FIA table to compute content damage for residential structures. (See TABLES H-13 and H-14 for residential depth-percent damage data.) Contents are assumed to include furniture, appliances, and domestic goods.

TABLE H 13

STE. GENEVIEVE
FEDERAL INSURANCE ADMINISTRATION "DEPTH DAMAGE CURVES: 1974"

RESIDENTIAL STRUCTURES

Depth In Feet	One Story No Basement (01)	Two or More Stories No Basement (03)	Split Level No Basement (05)	Split Foyer (07)	Mobile Homes (10)	One Story Dug Basement (13)	One Story Walkout Basement (15)	Two or More Stories Dug Basement (18)	Two or More Stories Walkout (14)	Split Level Dug Basement (23)	Split Leve Walkout Basement (25)
-4	0%	0%	0%	0%	0%	0%	9%	0%	6%	0%	3%
-3	0	0	0	5	0	0	11	0	7	0	6
-2	0	0	0	7	0	4	18	3	11	0	16
-1	0	0	0	9	0	8	20	3	17	5	19
0	7	5	3	11	8	11	23	7	22	6	22
1	10	9	9	18	45	18	28	11	28	16	27
2	14	13	13	20	64	20	33	17	33	19	32
3	26	18	25	23	74	23	38	22	35	22	35
4	28	20	27	28	79	28	44	28	38	27	36
5	29	22	28	33	80	33	49	33	40	32	44
6	41	24	33	38	81	38	51	35	44	35	48
7	43	26	34	44	82	44	53	38	46	36	50
8	44	31	41	49	82	49	55	40	48	44	52
9	45	36	43	51	82	51	57	44	50	48	54
10	46	38	45	53	82	53	59	46	52	50	56
11	47	40	46	55	82	55	60	48	54	52	58
12	48	42	47	57	82	57	60	50	56	54	59
13	49	44	48	59	82	59	60	52	58	56	60
14	50	46	49	60	82	60	60	54	58	58	60
15	50	47	50	60	82	60	60	56	58	59	60

SOURCE: Federal Insurance Administration, Flood Hazard Factors, Depth Damage Curves, Elevation - Frequency Curves, Standard Rate Tables, January 21, 1974

TABLE H 14

STE. GENEVIEVE
FEDERAL INSURANCE ADMINISTRATION "DEPTH-DAMAGE CURVES: 1974"

RESIDENTIAL CONTENTS[1/]

Depth In Feet	One Story No Basement (01)	Two or More Stories No Basement (03)	Split Level No Basement (05)	Split Foyer (07)	Mobile Homes (10)	One Story Dug Basement (13)	One Story Walkout Basement (15)	Two or More Stories Dug Basement (18)	Two or More Stories Walkout (14)	Split Level Dug Basement (23)	Split Level Walkout Basement (25)
-4	0%	0%	0%	0%	0%	0%	13%	0%	9%	0%	5%
-3	0	0	0	8	0	0	15	0	11	0	11
-2	0	0	0	11	0	7	20	9	17	0	17
-1	0	0	0	13	0	8	22	11	22	17	22
0	10	7	11	15	3	15	28	17	28	22	28
1	17	9	17	20	27	20	33	22	33	28	33
2	23	17	22	22	50	22	39	28	39	33	39
3	29	22	28	28	65	28	44	33	44	39	44
4	35	28	33	33	71	33	50	39	49	44	49
5	40	33	39	39	76	39	55	44	55	49	55
6	45	39	44	44	78	44	60	49	61	55	61
7	50	44	49	50	79	50	60	55	64	61	64
8	55	50	55	55	81	55	60	61	71	64	71
9	60	55	61	60	83	60	60	64	76	71	76
10	60	58	64	60	83	60	60	71	78	76	78
11	60	65	71	60	83	60	60	76	79	78	79
12	60	72	76	60	83	60	60	78	80	79	80
13	60	78	78	60	83	60	60	79	81	80	81
14	60	79	79	60	83	60	60	80	81	81	81
15	60	80	80	60	83	60	60	81	81	81	81

1/ Content values = 1/2 structure value.

SOURCE: Federal Insurance Administration, Flood Hazard Factors, Depth Damage Curves, Elevation - Frequency Curves, Standard Rate Tables, January 21, 1974

Miscellaneous damages associated with each structure type were computed to be 30 percent of the sum of existing structural and content damages. The justification for use of this percentage rate was computed by analyzing miscellaneous depth-damage and frequency-damage curves for a typical urban area and two distinct miscellaneous categories. The categories were:

(1) damages associated with households; and

(2) damages associated with community infrastructure.

Household miscellaneous damages include damages to the following items:

-Personal papers	-Temporary relocations	-Lawn mowers
-Auto	-Fences	-Clean-up
-Storage sheds	-Shrubs	-Building inspections
-Additional travel due to re-route	-Patios	-Driveways
-Lost gasoline	-Carport/garages	-Utility re-inspection
-Re-seeding	-Trees	-Demolition of structure
-Erosion		

A sample of 100 household structures in a typical urban setting was inventoried and damages were analyzed for various depths of flood water considering a typical landscaping, with typical distribution and locations of damageable items. Delayed damages were also included, such as cracking of driveways and patios, rusting of storage sheds, and wet-rotting or warping of wooden structures which may show up much later than the normal flood damages.

Infrastructure miscellaneous damages are those associated with community integrity. They include loss of, damage to, or expenses associated with the following:

-Street lights	-Streets	-Parks/playgrounds facilities
-Water mains	-School closings	-Bridges
-Water laterals	-Telephone outlets	-Police/fire/medical
-Gas mains	-Sewers	-National Guard
-Gas laterals	-Catch basins	-Traffic re-route
-Disconnect and reconnect utilities	-Telephone poles	-Sidewalks
	-Street clean-up	

Typical neighborhood characteristics, i.e., number of telephone poles, width of streets, linear feet of sewers per square mile, et al., were also inventoried. The means and magnitude of damages were evaluated using engineering judgment, actual data when available, and regional economic information. Delayed damages were again considered.

When household and infrastructure depth-damages were aggregated and tied to frequency, a sensitivity test was conducted for various structures. Three average annual miscellaneous damage estimates resulted: 29 percent, 39 percent, and 30 percent of the sum of structure

plus content damages. The mean of all three was 33 percent. A 30 percent value was selected for use.

Damage items that may not be included in the miscellaneous inventory but which the community or an individual nonetheless may incur include the following:

-Mail boxes and contents damage
-Road signs
-Billboard damage
-Electricity losses
-Costs associated with the purchase of a new home (Moving etc.)

-Lost drinking water
-Stop lights
-Lost natural gas
-Lost wages
-Park equipment damage (Lawnmower, Tractor, Trucks)

-Bus service disruption (lost revenue)
-Fire damages
-Lost taxes
-Real estate transaction costs (points, commissions, etc.)

These items were not evaluated for various reasons, including variability in values, location problems, and the lack of sufficient and/or adequate data.

3.1.4 Commercial/Industrial Damage Curves.

Commercial/industrial real estate values were estimated by using "Boeckh General Estimate Manual" (Boeckh Publications - A Division of the American Appraisal Company, Inc.) and on-site field surveys of local building costs in the Ste. Genevieve study area.

Commercial damages also include structural, content, and miscellaneous damage calculations. Commercial establishments are constructed of the same materials as residential structures, i.e. brick, wood, tile. Consequently, it was believed that the "typical" commercial structure would be damaged in a manner similar to that of a one story no basement residence and the appropriate FIA residential structure damage curve was matched to commercial structures Coded 101 thru 116. However, not all commercial structures were assumed to be similar to a one story-no basement residence. Structure types 117 thru 123 were developed independently. TABLE H-15 displays structures 101 thru 116 to be identical curves. The table maintains the format presented for residential structure damage curves.

The commercial content damage curves were developed from interviews with proprietors. These interviews focused on commercial groups, content, location, and damageability of inventory. For example, eight gas station owners/managers were interviewed for structure value, square footage of floor space, equipment and inventory value, annual sales, et al. Similar field inventories were conducted for churches, shoe repair shops, quick food stores, grocery stores, drug stores and pharmacies, laundry, cleaners, et al. Commercial establishments in Ste. Genevieve were matched with the damage codes developed for similar structure types.

The miscellaneous damage calculation of 30 percent of the combined structural plus content damages were again used in the determination of total commercial damages. See TABLES H-15 and H-16 for commercial depth-percent damage data.

3.1.5 Agricultural Damages.

Agricultural activity within the study area is limited to the bottomland floodplain between the Mississippi River and the town of Ste. Genevieve. This area consists of 1040 crop acres of which 325 acres are partially protected by the Ste. Genevieve County Levee District No. 2 from approximately the eight year flood on the Mississippi River. The remaining 715 acres are unprotected.

Crop production is limited to food and feed grain row crops such as corn, wheat, and soybeans. Yield ranges for the various crops are 90-100 bushels per acres for corn, 40-45 bushels per acre for wheat, and 35-40 bushels per acres for soybeans.

Since agricultural damages are incidental to the total flood damage within the study area and as much as fifty percent of the cropland would either be used as levee borrow and right-of-way or remain unprotected, no detailed analysis of crop damages was performed. Crop damage factors

TABLE H-15

STE. GENEVIEVE
DEPTH DAMAGE CURVES

COMMERCIAL STRUCTURES

Structure Type

First Floor Water Depth In Feet	(101) Gas Station	(102) Gas Station Services	(103) Drug Grocery Chain Food	(104) Disc. & Dept. Stores	(105) H'ware, Paint, Auto, Sport Stores	(106) Barber & Beauty Shops	(107) Laundry-Cleaners	(108) Quick Shops, Bakeries	(109) Fast Food, Dairy Queen Etc.	(110) Restaurants & Large Fast Food (McDonald's)	(111) Fashion Shoe Etc.	(112) Liquor Stores, Taverns	(113) Bowling Alleys	(114) Ware-house Storage Bldg.
-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0% •	0%	0%	0%
-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	7	7	7	7	7	7	7	7	7	7	7	7	7	7
1	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	14	14	14	14	14	14	14	14	14	14	14	14	14	14
3	26	26	26	26	26	26	26	26	26	26	26	26	26	26
4	28	28	28	28	28	28	28	28	28	28	28	28	28	28
5	29	29	29	29	29	29	29	29	29	29	29	29	29	29
6	41	41	41	41	41	41	41	41	41	41	41	41	41	41
7	43	43	43	43	43	43	43	43	43	43	43	43	43	43
8	44	44	44	44	44	44	44	44	44	44	44	44	44	44
9	45	45	45	45	45	45	45	45	45	45	45	45	45	45
10	46	46	46	46	46	46	46	46	46	46	46	46	46	46
11	47	47	47	47	47	47	47	47	47	47	47	47	47	47
12	48	48	48	48	48	48	48	48	48	48	48	48	48	48
13	49	49	49	49	49	49	49	49	49	49	49	49	49	49
14	50	50	50	50	50	50	50	50	50	50	50	50	50	50
15	50	50	50	50	50	50	50	50	50	50	50	50	50	50

SOURCE: St. Louis District Personnel Developed.

TABLE H-15
(cont'd)

STE. GENEVIEVE
DEPTH-DAMAGE CURVES

COMMERCIAL STRUCTURES

Structure Type

Depth In Feet	(115) General Office Space Doctors, Bank, Etc.	(116) Schools	(117) Grain Elevator	(118) Farm Shed	(119) Barn	(120) Silo	(121) Grain Bin	(122) Hog Feeder	(123) Feed/Seed Processor
-4	0%	0%	0%	0%	0%	0%	0%	0%	0%
-3	0	0	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0
0	7		8	10	9	15	15	10	8
1	10	10	22	20	21	20	20	20	22
2	14	14	30	30	30	22	23	30	30
3	26	26	35	40	37	24	26	40	35
4	28	28	39	50	45	26	29	50	39
5	29	29	41	60	50	28	32	60	41
6	41	41	44	70	56	30	35	70	44
7	43	43	47	80	63	32	38	80	47
8	44	44	50	89	65	34	40	89	50
9	45	45	53	91	65	36	40	91	53
10	46	46	56	91	65	38	40	91	56
11	47	47	58	91	65	40	40	91	58
12	48	48	60	91	65	40	40	91	60
13	49	49	60	91	65	40	40	91	60
14	50	50	60	91	65	40	40	91	60
15	50	50	60	91	65	40	40	91	60

SOURCE: St. Louis District Personnel Developed.

TABLE H-16

STE. GENEVIEVE
DEPTH-DAMAGE CURVES

COMMERCIAL CONTENTS[1/]

Structure Type

First Floor Water Depth In Feet	(101) Gas Station	(102) Gas Station Services	(103) Drug Grocery Chain Food	(104) Disc. & Dept. Stores	(105) H'ware, Paint, Auto, Sport Stores	(106) Barber & Beauty Shops	(107) Laundry-Cleaners	(108) Quick Shops, Bakeries	(109) Fast Food, Dairy Queen Etc.	(110) Restaurants & Large Fast Food (McDonald's)	(111) Fashion Shoe Etc.	(112) Liquor Stores, Taverns	(113) Bowling Alleys	(114) Ware-house Storage Bldg.
-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	14	42	17	3	13	0	0	36	2	6	4	5	20	01
1	14	58	74	20	48	2	41	107	5	10	26	12	41	35
2	16	74	97	37	77	3	69	149	8	19	48	19	71	152
3	25	90	120	41	90	7	87	192	10	25	53	26	89	199
4	26	96	143	55	105	8	98	235	13	27	72	33	100	246
5	26	105	165	62	111	9	161	278	15	30	81	38	118	293
6	26	109	168	63	112	9	161	284	17	34	82	42	118	340
7	26	112	173	65	119	9	161	290	18	36	84	45	118	348
8	26	116	176	66	123	9	161	296	21	39	86	53	118	355
9	26	118	180	68	127	9	161	303	21	39	88	53	118	370
10	26	120	184	69	131	9	161	308	21	39	89	53	118	370
11	26	120	184	69	131	9	161	308	21	39	89	53	118	378
12	26	120	184	69	131	9	161	308	21	39	89	53	118	378
13	26	120	184	69	131	9	161	308	21	39	89	53	118	378
14	26	120	184	69	131	9	161	308	21	39	69	53	118	378
15	26	120	184	69	131	9	161	308	21	39	89	53	118	378
16	26	120	184	69	131	9	161	308	21	39	89	53	118	378
17	26	120	184	69	131	9	161	308	21	39	89	53	118	378
18	26	120	184	69	131	9	161	308	21	39	89	53	118	378

1/ Content Value - 1/2 Structure Value

SOURCE: St. Louis District Personnel Developed

TABLE H-16
(cont'd)

STE. GENEVIEVE
DEPTH-DAMAGE CURVES

COMMERCIAL CONTENTS[1/]

Structure Type

Depth In Feet	(115) General Office Space Doctors, Bank, Etc.	(116) Schools	(117) Grain Elevator	(118) Farm Shed	(119) Barn	(120) Silo	(121) Grain Bin	(122) Hog Feeder	(123) Feed/Seed Processor
-4	0%	0%	0%	0%	0%	0%	0%	0%	0%
-3	0	0	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0
0	1	1	35	13	11	9	9	8	50
1	2	2	152	15	22	18	18	10	100
2	3	3	199	25	33	27	27	12	150
3	4	4	246	35	44	36	36	14	200
4	4	4	293	45	55	45	45	16	250
5	5	5	340	55	66	54	54	18	300
6	6	6	348	65	77	63	63	19	350
7	7	7	355	75	88	72	72	20	400
8	7	7	370	85	99	81	81	21	450
9	8	8	370	95	110	90	90	22	500
10	9	9	378	99	121	99	99	23	550
11	9	9	378	99	132	108	108	24	600
12	9	9	378	99	143	117	117	25	650
13	9	9	378	99	154	126	126	26	700
14	9	9	378	99	165	135	135	27	750
15	9	9	378	99	176	144	144	28	800

1/ Content Value = 1/2 Structure Value

SOURCE: St. Louis District Personnel Developed

from a similar area 24 miles downstream of the Ste. Genevieve Study area were applied to the site specific average annual acres flooded.[2]

3.2 FLOOD DAMAGE ANALYSIS AND EVALUATION

St. Louis District Corps of Engineer's Urban Damage II program expresses the results of flood damage calculations in two forms: single event and average annual damages.

a. Single event damages are damages resulting from a flood of known probability of occurrence, such as the 1-percent chance flood event which has a one percent chance of occurring in any given year and is termed a 100-year frequency flood.

b. Average annual damages are the amount of damage that can be expected yearly on average, based on the full range of flood events over a long period of time under a given set of physical conditions.

Single-event calculations are performed automatically by the Urban Damage II computer program using the frequency profiles (stage-frequency) from HEC-2. The elevations of the profiles at a structure location are interpolated from the profiles at cross section locations immediately up

[2] U.S. ARMY CORPS OF ENGINEERS, ST. LOUIS DISTRICT, Letter Report for Interior Flood Control and Allied Purposes, Degognia-Fountain Bluff and Grand Tower Drainage and Levee District, Jackson County, Illinois, June 1981.

and downstream of the river mile location of the structure. When these elevations are combined with the stage-damage curves for each structure type, a damage-frequency curve is developed. Average annual damages are then computed by determining the area under the damage versus frequency curve. These damages represent the average yearly damage for a particular set of hydrologic, hydraulic, and damage conditions.

3.2.1 Damages From Actual Flood Events

Significant flood damages in the St. Genevieve area do not occur until flooding nears the 10-year frequency event on the Mississippi River. Recent floods of 1979 and 1982 were considered to fall between the 10 and 25-year frequency events. The flood of 1973 has been classed as a 30-year event. In 1973 newspaper accounts and Corps of Engineer estimates of urban related damages both approximated $1.5 million. This differs from the $3.0 million loss quoted in the Main Report. That estimate included business and agricultural losses which are not included in the $1.5 million stated here. The Corps of Engineers damage estimates were determined from actual field surveys after the 1973 flood. Adjusting for price level increases, the urban damage estimate of $1.5 million compares favorably with present Urban Damage II damage estimates of $3.3 million for a 30-year frequency flood.

The flood of 1982 has been assigned a 20-year frequency and newspaper accounts have quoted $2.4 million in damages. Some of that damage figure ($700,000 estimated to repair the failure of a section of the sewage lagoon embankment) came from a Corps of Engineer estimate developed while

assisting the FEMA agency in their efforts to aid the President in disaster declarations. Urban Damage II results from a 20-year frequency event yielded $2 million to urban structures only. There is a rather dramatic change in damages between the Mississippi River 10 and 25 year frequency events. Considering the difficulty in assigning a frequency to any actual flood event and the tendency to round to the nearest 5 or 10 when describing a frequency, it is felt that Urban Damage II results correlate well for the 1982 flood also.

3.2.2 Existing Development Flood Damages

The floc . damage determinations required many iterations of the Urban Damage II model to assure confidence in its computations and output. Field surveys were conducted to verify questionable high damage areas and their associated buildings. Continuous revisions were necessary to correct errors in first floor elevations, structure damage codes, river mile location, and structure values. Each structure was matched with a depth damage curve judged to be an appropriate fit for expected damages, i.e. some warehouses were discovered to be vacant structures and consequently, were re-classified and given a damage code which zeroed out contents. Also, residential structures classified as walkout basements were found to have cellar type exits and were re-classified a "dug basement" type.

Approximately 700 structures (500 residential) were inventoried in the Ste. Genevieve Study area. Of the 700 inventoried, approximately 500 (390 Residential) will be damaged with a SPF or Urban Design Flood occurrence either on the creeks or on the Mississippi River. TABLE H-17 illustrates total existing average annual damages and number of buildings damaged by area due to Mississippi River flooding and flooding by the North and South Gabouri Creeks. TABLE H-17 also indicates that 483 out of a maximum of 509 structures susceptible to flooding can be damaged by both the Mississippi River and the Gabouri Creeks. TABLE H-18 summarizes by area and structure type the average value of those structures damaged and the average annual damage per structure. TABLE H-19 shows the average annual damages broken down by structure, content, and miscellaneous categories, and also accounts for future-without conditions which includes an increase in content damage due to affluence. Affluence effects are discussed below under paragraph 3.2.4, Future Conditions Flood Damage.

Average annual damages to commercial and residential structures caused by either North or South Gabouri Creek and the Mississippi River have been added together to account for total annual damages to those structures susceptible to flooding from both sources. This of course assumes that each structure can only be damaged by one source of flooding at a time. This report has not attempted to evaluate the annual damages

TABLE H-17
SECOND ITERATION
AVERAGE ANNUAL DAMAGES BY TRIBUTARY AND AREA*
(EXISTING = FUTURE WITHOUT CONDITIONS)
SPF FLOOD FREQUENCY**
(OCTOBER 1982 Dollars)

	Mississippi River		North Gabouri		South Gabouri		TOTALS	
AREA	NO. BLDS. DAMAGED	AAD	NO. BLDS. DAMAGED	AAD	NO. BLDS. DAMAGED	AAD	NO. BLDS. DAMAGED	AAD
I Commercial	7	$ 5,000			3	$18,000	8	$23,000
Residential	59	9,000			16	9,000	63	18,000
II Commercial	73	217,000	33	$11,000	5	31,000	76	259,000
Residential	148	45,000	60	6,000	60	14,000	163	65,000
III Commercial	20	28,000	9	2,000			20	30,000
Residential	160	40,000	108	11,000			163	51,000
500	16	13,000					16	13,000
TOTAL								
Commercial	116	263,000	42	13,000	8	49,000	120	325,000
Residential	367	94,000	168	17,000	76	23,000	389	134,000
TOT.	483	$357,000	210	$30,000	84	$72,000	509	$459,000

* Affluence factor not included.

** Number of buildings damaged are for SPF flood frequency on North and South Gabouri Creek and Urban Design (500-Year frequency) for Mississippi River results. North and South Gabouri Creek Hydraulic Profiles assume a low water surface on the Mississippi River.

TABLE H-18
SECOND ITERATION
Selected Damage Data By Area
(October 1982 Dollars)
Mississippi River Hydraulic Profile

Area		# Structures Damaged*	AAD**	Average Value Structure***	AAD/Per Structure
Residential	Area 1	59	$ 9,000	$22,700	$ 150
	Area 2	148	45,000	22,500	300
	Area 3	160	40,000	20,400	250
Commercial	Area 1	7	5,000	43,000	710
	Area 2	73	217,000	56,800	2,970
	Area 3	20	28,000	32,900	1,400
Area 500		16	13,000	13,700	810
		483	$357,000	27,400	740
South Gabouri Creek Hydraulic Profile					
Residential	Area 1	16	$ 9,000	$ 14,500	$ 560
	Area 2	60	14,000	24,400	230
Commercial	Area 1	3	18,000	39,000	6,000
	Area 2	5	31,000	237,600	6,200
		84	72,000	35,700	860
North Gabouri Creek Hydraulic Profile					
Residential	Area 2	60	$ 6,000	$19,700	$ 100
	Area 3	108	11,000	12,100	100
Commercial	Area 2	33	11,000	33,200	330
	Area 3	9	2,000	18,300	220
		210	30,000	18,000	140

* Number of structures damageable at the Urban Design Flood for the Mississippi River or SPF Flood For the Gabouri Creeks.

** Average Annual Damages.

*** Average Value per Structure of those Structures damaged

TABLE H-19
STE. GENEVIEVE
AVERAGE ANNUAL DAMAGES
EXISTING AND FUTURE WITHOUT CONDITIONS BY DAMAGE CATEGORY

	RESIDENTIAL	COMMERCIAL	ALL STRUCTURES
Structure AAD			
Mississippi	$41,000	$78,000	
N. Gabouri	7,000	3,000	
S. Gabouri	9,000	13,000	
Total Structure AAD (Existing)	$57,000	$94,000	$151,000
Content AAD			
Mississippi	$31,000	$124,000	
N. Gabouri	6,000	7,000	
S. Gabouri	9,000	25,000	
Total Content AAD (Existing)	$46,000	$156,000	$202,000
Affluence Factor (Future without)	$66,000	$156,000	$222,000
Miscellaneous AAD			
Mississippi	$22,000	$61,000	
N. Gabouri	4,000	3,000	
S. Gabouri	5,000	11,000	
Total Misc. AAD (Existing)	$31,000	$75,000	$106,000
Affluence Factor (Future without)	$37,000	$75,000	$112,000
TOTAL AAD (Existing)	$134,000	$325,000	$459,000
TOTAL AAD (Future Without)	$160,000	$325,000	$485,000

AAD = Average Annual Damages

or benefits associated with joint occurrence or concurrent flooding of either creek with the Mississippi River. Although concurrent events can in fact happen, they cannot easily be evaluated. The probability of such an occurrence is actually the product of the probabilities one might consider on each stream. For example, a stage-frequency curve consisting of 2, 5, 10, 25, 50, and 100 years, and SPF events from a creek interacting with a similar stage-frequency from the Mississippi River involves forty-nine occurrence possibilities, the probability of each being the product of their independent probabilities. A further difficulty presents itself when one attempts to define a water surface profile or assign an elevation or depth of water corresponding to this new frequency of occurrence. When concurrent flooding occurs and water surface profiles intersect, it can be reasoned that the creek profile is affected by loss of storage due to backwater effects from the Mississippi and likewise the Mississippi backwater is affected by the creek profile depriving it of storage. Therefore, a specific frequency of occurrence on each stream when combined can produce a higher elevation of water then either individual frequency produces. The length of the river or creek over which this effect is felt is also difficult to evaluate. This new elevation would obviously cause additional damages over affected reaches of the river and creek. Therefore, damages may be understated from this standpoint because damages due to this effect have not been included. On the other hand, however, we have captured at least the independent effects of the creeks and river and, in fact, by adding them, have overstated their effect by not accounting for joint occurrence reduction.

Given that concurrent events are related by the product of their event probabilities, and given the reality of a period of record of 44 years without a coincidental flood occurrence, average annual damages and benefits are not believed to be either understated or overstated by a significant amount.

TABLES H-20 thru H-22 illustrate total existing event damages and number of buildings damaged by area due to Mississippi River flooding and flooding by North and South Gabouri Creeks.

TABLES H-18 and H-20 thru H-22 indicate that a 500 year frequency event on the Mississippi River would result in $9.8 million in damages to 483 structures, 25 percent of which are commercial buildings accounting for $5.7 million (58%) of those damages. Average annual damages for the 483 structures are $357,000 or damages of approximately $740 per structure annually for existing conditions.

SPF flooding from North Gabouri Creek would result in $2.4 million in damages to 210 structures, 20 percent of which are commercial buildings accounting for 38% or in excess of $900,000 of those damages. Average annual damages for the 210 structures are $30,000 or damages of approximately $140 per structure annually for existing conditions.

TABLE H-20
SECOND ITERATION
TOTAL DAMAGES BY FREQUENCY AND AREA
(MISSISSIPPI RIVER HYDRAULIC PROFILE)
(EXISTING = FUTURE WITHOUT CONDITIONS)
(OCTOBER 1982 DOLLARS)

AREA	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR*
I Commercial	0	0	$ 8,200	$ 37,100	$ 69,300	$ 108,900	$ 251,200
Residential	0	0	4,200	32,900	113,400	288,700	640,400
II Commercial	0	600	603,300	1,993,000	2,752,300	3,306,300	4,075,700
Residential	0	2,900	66,800	345,900	638,200	980,300	1,608,400
III Commercial	0	0	6,300	141,800	580,000	890,900	1,151,900
Residential	0	0	25,500	265,000	635,600	1,069,500	1,792,800
500	0	0	36,400	119,000	181,700	216,000	252,600
Total Commercial	0	600	654,200	2,290,900	3,583,300	4,522,100	5,731,400
Residential	0	2,900	96,500	643,800	1,387,200	2,338,500	4,041,600
TOTAL	0	3,500	750,700	2,934,700	4,970,500	6,860,600	9,773,000
NUMBER OF BUILDINGS DAMAGED BY FREQUENCY AND AREA							
I Commercial	0	0	1	1	4	5	7
Residential	0	0	2	12	29	50	59
II Commercial	0	1	17	45	52	63	73
Residential	0	7	28	64	79	104	148
III Commercial	0	0	3	12	17	18	20
Residential	0	0	18	64	97	121	160
500	0	0	2	12	16	16	16
TOTAL Commercial	0	1	23	70	89	102	116
Residential	0	7	48	140	205	275	367
TOTAL	0	8	71	210	294	377	483

*Urban design flood frequency

TABLE H 21
SECOND ITERATION
TOTAL DAMAGES BY FREQUENCY AND AREA
(NORTH GABOURI CREEK HYDRAULIC PROFILE*)
(EXISTING = FUTURE WITHOUT CONDITIONS)
(OCTOBER 1982 DOLLARS)

AREA	2 YR	5 YR	10-YR	25-YR	50-YR	100-YR	500-YR	SPF**
II Commercial	$ 0	$ 0	$14,200	$ 80,400	$167,700	$216,700	$ 426,700	$ 755,700
Residential	0	0	10,300	38,100	78,300	127,800	312,300	577,200
III Commercial	0	0	0	1,200	25,100	44,200	112,900	168,100
Residential	1,000	10,400	20,400	39,600	93,000	162,700	452,300	924,600
TOTAL Commercial	0	0	14,200	81,600	192,800	260,900	539,600	923,800
Residential	1,000	10,400	30,700	77,700	171,300	290,500	764,600	1,501,800
TOTAL	1,000	10,400	44,900	159,300	364,100	551,400	1,304,200	2,425,600
NUMBER OF BUILDINGS DAMAGED BY FREQUENCY AND AREA								
II Commercial	0	0	4	5	6	8	19	33
Residential	0	0	6	13	24	29	47	60
III Commercial	0	0	0	1	5	6	9	9
Residential	1	5	8	20	37	55	82	108
TOTAL Commercial	0	0	4	6	11	14	28	42
Residential	1	5	14	33	61	84	129	168
TOTAL	1	5	18	39	72	98	157	210

*Assumes Low Water on Mississippi River

**Approximately 2,000-Year flood frequency

TABLE H 22
SECOND ITERATION
TOTAL DAMAGES BY FREQUENCY and AREA
(SOUTH GABOURI CREEK HYDRAULIC PROFILE*)
(EXISTING = FUTURE WITHOUT CONDITIONS)
(OCTOBER 1982 DOLLARS)

AREA	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR	SPF**
I Commercial	$ 0	$39,200	$ 54,200	$ 67,300	$ 76,000	$ 81,000	$ 108,000	$ 144,000
Residential	4,600	13,300	18,600	28,600	37,600	46,400	73,000	119,600
II Commercial	0	0	144,500	222,600	294,700	377,000	604,100	1,027,400
Residential	3,000	22,400	40,600	61,700	84,300	110,100	240,400	507,400
TOTAL Commercial	0	39,200	198,700	289,900	370,700	458,000	712,100	1,171,400
Residential	7,600	35,700	59,200	90,300	121,900	156,500	313,400	627,000
TOTAL	7,600	74,900	257,900	380,200	492,600	614,500	1,025,500	1,798,400
NUMBER OF BUILDINGS DAMAGED BY FREQUENCY AND AREA								
I Commercial	0	1	1	1	2	2	3	3
Residential	4	5	6	7	9	11	16	16
II Commercial	0	0	1	1	1	2	3	5
Residential	4	14	20	23	29	30	48	60
TOTAL Commercial	0	1	2	2	3	4	6	8
Residential	8	19	26	30	38	41	64	76
TOTAL	8	20	28	32	41	45	70	84

*Assumes Low Water on Mississippi River

**Approximately 5,000-Year flood frequency.

SPF flooding from South Gabouri Creek would result in $1.8 million in damages to 84 structures, 10 percent of which are commercial buildings accounting for 65 percent or $1.2 million of those damages. Average annual damages for the 84 structures are $72,000 or damages of approximately $860 per structure annually for existing conditions.

3.2.3 Crop Damages.

The first step in the analysis of crop damages was the determination of the relevant flood plain. Of the 1040 total acres in bottom land only 710 acres are part of the project area. The 710 acres consist of 385 acres of unprotected cropland and 325 acres of partially protected (from the eight year Mississippi River flood) cropland. The second step was the development of the area/elevation relationship for the relevant portion of the study area. United States Geological Survey quadrangle maps were planimetered to determine the acres below various elevations. From these discrete acreage/elevation data points, intermediate acreage/elevation values were estimated by curvilinear interpolation. TABLE H-23 reflects the representative elevations, acres, and exceedance frequencies of the unprotected portion of the agricultural flood plain.

TABLE H-23

BOTTOM LAND AREA/ELEVATION

ELEVATION (n.g.v.d.)	EXCEEDANCE FREQUENCY	ACRES
378'	2 year	77
383'	5 year	325
386'	10 year	385
390'	25 year	385
392'	50 year	385
395'	100 year	385
398'	500 year	385

From the data presented in TABLE H-23 above, it was determined that approximately 174 acres are flooded in the unprotected area on an average annual basis. The same analysis was performed in the partially protected area of 325 acres which yielded 40 average annual acres flooded. Thus, the total average annual crop acres flooded in the study area are 214 acres.

The third step in determining existing condition crop damages was the application of the dollar damage per acre flooded factor. As mentioned previously (see Footnote 2), crop damages data were extrapolated from a similar area downstream of the study area which yielded a damage factor

of $120 per acre flooded. Combining the damage factor with the 214 average annual acres flooded results in a total existing condition crop damage of $25,700 average annual.

3.2.4 Future Conditions Flood Damage

Future without project hydraulic conditions were determined to be the same as existing conditions. No significant development of the flood plain is anticipated and future runoff conditions are expected to remain constant. This conclusion was drawn following an evaluation which included the following considerations. There has in the past been local discouragement of development in the Ste. Genevieve old town area to allow for preservation of the historic features. Large scale development has not and is not expected to take place. In addition, the new development that has taken place has been to the west of Highway 61 and future development is expected to continue in that direction. The only additional damages to be accounted for under future without project conditions are those increases which would occur to residential contents because of a general increase in content value over time due to affluence. Residential content value was allowed to increase with time from the existing 50 percent of structure value to 75 percent of the structure value at a growth rate of 2.1 percent derived from the OBER's per capita personal income projections for the region. The 75 percent

ceiling on residential contents was reached within 9 years of the 1990 base year. (See 1980 OBERS BEA Regional Projections for the State of Missouri, Vol 7, Page 56.) The effect of affluence on damages in a future without project condition are shown on TABLE H-19.

3.2.5 Crop Damages Future

Unlike the existing value of structural damage, the agricultural damages will increase over time. This increased damage value is directly related to the increase in crop yields over the life of the project. However, due to the uncertainties involved in such long term projections, only a fifty year projection was made with the fifty year value held constant for the remaining project life. The discounted stream of these future increases can be expressed as a percentage growth rate which, when applied to the existing condition damages, will yield the value of damage to future crop production. As discussed above, no detailed agricultural damage analysis was performed, however, data from a similar area 24 miles downstream of the study area were extrapolated to represent appropriate values for Ste. Genevieve. The appropriate growth factor was determined to be 1.17 times the existing condition damages of $25,700 which results in a future conditions damage of $30,100.

SECTION 4 - BENEFITS ANALYSIS

4.1 ECONOMIC BENEFITS

The primary economic benefit to any plan of protection for the Ste. Genevieve study area is the amount of reduction of urban flood damages. Other benefit categories were considered and are discussed; but none are as significant as those benefits attributable to inundation reduction. Nevertheless, as will be discussed below, the magnitude of the directly quantifiable benefits on this project were not sufficient to support project justification. Rationale for project justification and continuation based on non-quantifiable benefits can be found in Volume One, Main Report.

4.1.1 Flood Damage Reduction Benefits

Average annual damage reduction benefits are equal to the difference in average annual flood damages that would be expected to occur without the proposed improvements and residual average annual damages that would be expected to occur with the proposed improvements. Average annual damages and benefits were computed using the Urban Damage II Program discussed above in Paragraph 3.1.

This program evaluates damages "with" and "without" a particular plan of improvement in-place and computes inundation reduction benefits. The program allows the user to raise, remove, or add protection to individual structures or provide a levee protection to any frequency level desired. When a channel widening alternative is considered, the Hydraulic Profile input to Urban Damage II reflects the water surface profile for that solution and, therefore, affects the resulting damage/benefit computations.

4.1.2 Future Benefits.

Future benefit categories discussed below include intensification and location benefits, lost business, and redevelopment benefits. Other future benefits have been discussed above, namely those future benefits resulting from affluence effects on content values (Para 3.2.4) and increased damage value related to an increase in crop yields over the life of the project (Para. 3.2.5).

4.1.3 Intensification And Location Benefits.

Location and intensification benefits attributable to a project are direct primary benefits from increased use of land through either intensified activities or by changing land use to an economically higher state of development than would occur in the absence of the project.

Such benefits result because of the higher utilization made feasible by increased rates of return on higher levels of investment. Any benefits relating to intensification and/or location for this study would be tied to the recreational opportunities made possible by protecting the historic home sites. If a plan were developed that utilized the unique location of Ste. Genevieve (the historic setting as the first settlement west of the Mississippi) and intensified the development of a historic district that included enhancement of the historic homes coupled with perhaps an amusement park and accommodations for large numbers of visitors, then a benefit category could be developed for these factors.

In order to do so, the existence of some general plan with a valid sponsor with the ability to finance and acquire land and to develop the necessary facilities would be required. It is recognized that certain homes may in fact be restored and developed as a matter of course. No indication can be found, however, that would point to large scale development. Therefore, in the absence of adequate indication that the above will take place, and considering the relatively small benefits that could be derived from this benefit category, these benefits were not developed.

4.1.4 Loss of Business.

Any determination of loss of business would be tenuous at best. First of all, the loss must be absolute, that is, permanently lost and not recoverable. Secondly, it cannot be transferred elsewhere. In the

case of commercial products or services, customers generally buy someplace else - say west of the flooded portion of town. In other cases, the customer will postpone the purchase until after the flood. In the area of lost recreation opportunities, the local recreator could postpone the visit. Essentially, the only measurable lost business benefit would be the tourist, who in the course of driving through the area, would be prohibited from visitation due to flooding and this recreation dollar expenditure would be permanently lost to the local economy. Given the small magnitude of such dollars, no quantification was deemed appropriate.

4.1.5 Redevelopment.

There are no redevelopment (employment) benefits applicable to the Ste. Genevieve study area. Neither Ste. Genevieve County nor the city of Ste. Genevieve qualify for the designation of "substantial and persistent" unemployment based on the criteria established by the Economic Development Administration under subsection 1 of Title IV of the Public Works and Economic Development Act of 1965 (Public Law 89-136, as amended).

4.2 ECONOMIC ANALYSIS OF MEASURES

4.2.1 First Iteration.

The Ste. Genevieve study was conducted in two planning iterations.

Data were continually being refined and therefore flood damage reduction measures developed during each iteration were evaluated against the damage calculation current at that time. Measures 1 thru 8 and 20 and 21 were evaluated against first iteration damage calculations.

The results of first iteration damage computations for existing conditions are shown by event for each stream and the Mississippi River on TABLES H-24, H-25, and H-26. A summary of the average annual damages is shown on H-27. The TABLES developed during first and second iteration phases of this study effort excluded the effect of affluence on damage value. During these screening phases, it was not considered necessary because the effect of affluence would not differ for any measure considered and therefore would not favor the selection of any measure over another.

First iteration measures generally included levee/floodwall solutions with gravity drains and pump stations. Channelization of the Gabouri Creeks, except for diversion purposes to implement a levee measure, was not considered during this first iteration. Each measure is discussed fully in APPENDIX A, Plan Formulation and will be discussed briefly in the following paragraphs relative to damages and benefits associated with each.

TABLE H-24
FIRST ITERATION
TOTAL DAMAGES BY FREQUENCY AND AREA
(Mississippi River Hydraulic Profile)
(Existing = Future Without Conditions)
(October 1982 Dollars)

AREA	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR*
I Commercial	0	0	$ 0	$ 37,300	$ 89,500	$ 130,400	$ 418,200
Residential	0	0	4,200	33,600	109,300	279,200	627,800
II Commercial	0	$ 2,000	200,600	2,111,700	2,871,000	3,416,300	4,302,500
Residential	0	3,300	49,000	317,200	615,800	978,200	1,618,000
III Commercial	0	0	7,500	174,700	724,100	1,039,900	1,238,000
Residential	0	0	21,800	254,800	617,700	1,071,800	1,819,500
500	0	0	45,600	131,600	184,000	219,400	251,300
TOTAL Commercial	0	2,000	253,700	2,455,300	3,868,600	4,806,000	6,210,000
Residential	0	3,300	75,000	605,600	1,342,800	2,329,200	4,065,300
TOTAL	0	5,300	328,700	3,060,900	5,211,400	7,135,200	10,275,300
NUMBER OF BUILDING DAMAGED BY FREQUENCY AND AREA							
I Commercial	0	0	1	1	4	5	8
Residential	0	0	2	12	27	46	56
II Commercial	0	1	14	45	52	63	73
Residential	0	4	25	63	79	105	147
III Commercial	0	0	3	12	17	19	21
Residential	0	0	17	65	96	123	160
500	0	0	2	12	16	16	16
TOTAL Commercial	0	1	19	70	89	103	118
Residential	0	4	44	140	202	274	363
TOTAL	0	5	63	210	291	377	481

*Urban Design Flood Frequency

TABLE H-25
FIRST ITERATION
TOTAL DAMAGES BY FREQUENCY AND AREA
(North Gabouri Creek Hydraulic Profile *)
(Existing = Future Without Conditions)
(October 1982 Dollars)

AREA	2-YR	5-YR	10-YR	25-YR	50 YR	100 YR	500-YR	SPF**
II Commercial	0	0	$21,800	$103,400	$164,100	$221,900	$467,100	$833,000
Residential	0	0	1,200	20,400	63,300	103,700	280,500	558,000
III Commercial	$ 0	$ 0	0	2,200	35,900	63,300	132,600	178,400
Residential	2,000	17,100	23,100	51,000	115,200	189,200	468,500	985,100
Total Commercial	0	0	21,800	105,600	200,000	285,200	599,700	1,011,400
Residential	2,000	17,100	24,300	71,400	178,500	292,900	749,000	1,543,100
TOTAL	2,000	17,100	46,100	177,000	378,500	578,100	1,348,700	2,554,500
NUMBER OF BUILDINGS DAMAGED BY FREQUENCY AND AREA								
II Commercial	0	0	3	4	5	10	18	33
Residential	0	0	4	10	23	27	45	60
III Commercial	0	0	0	2	6	7	10	10
Residential	1	3	3	22	37	55	81	110
TOTAL Commercial	0	0	3	6	11	17	28	43
Residential	1	3	7	32	60	82	126	170
TOTAL	1	3	10	38	71	99	154	213

* Assumes Low Water on Mississippi River
** Approximately 2,000-Year Frequency Floodplain

TABLE H 26
FIRST ITERATION
TOTAL DAMAGES BY FREQUENCY AND AREA
(South Gabouri Creek Hydraulic Profile*)
(Existing - Future Without Conditions)
(October 1982 Dollars)

AREA	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR	SPF**
I Commercial	$ 0	$52,500	$70,700	$79,100	$85,800	$91,800	$114,800	$147,600
Residential	11,400	21,200	28,200	39,000	46,200	54,700	78,400	121,400
II Commercial	0	0	0	0	0	1,800	377,000	1,089,300
Residential	4,200	26,500	55,100	84,000	110,300	142,000	265,000	591,700
TOTAL Commercial	0	52,500	70,700	79,100	85,800	93,600	491,800	1,236,900
Residential	15,600	47,700	83,300	123,000	156,500	196,700	343,400	713,100
TOTAL	15,600	100,200	154,000	202,100	242,300	290,300	835,200	1,950,000
NUMBER OF BUILDINGS DAMAGED BY FREQUENCY AND AREA								
I Commercial	0	1	1	1	2	2	3	3
Residential	4	5	7	8	8	10	13	13
II Commercial	0	0	0	0	0	1	3	5
Residential	5	14	20	21	28	30	46	58
TOTAL Commercial	0	1	1	1	2	3	6	8
Residential	9	19	27	29	36	40	59	71
TOTAL	9	20	28	30	38	43	65	79

* Assumes Low Water on Mississippi River
** Approximately 5,000-Year Frequency Floodplain

TABLE H-27
FIRST ITERATION
AVERAGE ANNUAL DAMAGES BY TRIBUTARY AND AREA
(EXISTING = FUTURE WITHOUT CONDITIONS)
SPF FLOOD FREQUENCY*
(OCTOBER 1982 Dollars)

AREA	Mississippi River NO. BLDS. DAMAGED	Mississippi River AAD	North Gabouri NO. BLDS. DAMAGED	North Gabouri AAD	South Gabouri NO. BLDS. DAMAGED	South Gabouri AAD	TOTALS NO. BLDS. DAMAGED	TOTALS AAD
I Commercial	8	$ 6,000			3	$22,000	9	$28,000
Residential	156	9,000			13	14,000	59	23,000
II Commercial	73	189,000	33	$12,000	5	3,000	75	204,000
Residential	147	42,000	60	5,000	58	18,000	162	65,000
III Commercial	21	32,000	10	2,000			21	34,000
Residential	160	39,000	110	13,000			161	52,000
500	16	14,000	—	—	—	—	16	14,000
TOTAL Commercial	118	241,000	43	14,000	8	25,000	121	280,000
Residential	363	90,000	170	18,000	71	32,000	382	140,000
TOTAL	481	$331,000	213	$32,000	79	$57,000	503	$420,000

* Number of buildings damaged are for SPF flood frequency on North and South Gabouri Creek and Urban Design (500-Year frequency) for Mississippi River results. North and South Gabouri Creek Hydraulic Profiles assume a low water surface on the Mississippi River.

With the exception of measures 6 and 8, each measure addressed protecting only one or two areas while excluding the others. Measures 20 and 21 are evacuation measures. Measure 20 considered removal of families flooded to or above the first floor level by the 10 year flood from the Mississippi River. There were 34 structures involved in Measure 20, 23 of which were to be destroyed and 11 to be relocated. Ten of the relocated structures were considered historical buildings. Two historical buildings were among those scheduled to be destroyed. Measure 21 involved relocation of 16 significant historical structures which were damaged at or above the first floor level or had water in their basements as a result of the 1973 flood.

Measures 1 through 4 were analyzed for the following three conditions:

a. 1973 flood on Mississippi river with a 50 year flood on Gabouri Creeks.

b. 100 year flood on Mississippi River with a 100 year flood on Gabouri Creeks.

c. 500 year Urban Design Flood on Mississippi River with a SPF flood on both Gabouri Creeks.

Measures 5 through 8 were also levee type plans located in the floodplain. The levees were designed and costed using standard and hydraulic fill construction. Levee heights provided protection from Mississippi River flooding at the 1973 (approximately 30 year frequency) level of protection, 100 year, and 500 year urban design flood levels.

These measures did not include at this stage provision for addressing the flooding possibilities on the two Gabouri Creeks.

TABLE H-28 lists the above measures, their inundation reduction benefits, costs, benefit-cost ratios, net benefits, and residual damages. TABLES H-29 and H-30 show the components of the benefit calculation as they are distributed to each stream and the Mississippi River. TABLE H-31 is a summary of first iteration annual economic benefits. Interest during construction for these initial measures was calculated for screening purposes in accordance with EM 1120-2-104, i.e., interest during construction was set equal to construction costs times the interest rate times one-half the construction period in years. It should be reiterated that refining of parameters used in the Urban Damage II program was taking place continually during this stage and costs, residual damages, and benefits reported during this iteration reflect these changes. These changes, however, in no way affected the conclusions which were drawn regarding the disposition of these measures for further study. In the final analysis, a 10 percent net increase in existing damages resulted from all changes to damage codes, stage damage curves, structure elevation changes, river mile location changes, and addition or removal of structures. Total damages increased from $420,000 to $459,000. (See TABLES H-17 and H-27.)

TABLE H-28

FIRST ITERATION SUMMARY

(in Thousands of October 1982 Dollars)

LEVEL OF PROTECTION

30 YEAR*

Measure	BEN.	COST	NET BEN.	B/C	RESIDUAL DAMAGES**
1	$ 27	$ 572	$- 545	.05	$ 14 ([illegible])
2	118	748	- 630	.16	207 (340)
3	29	680	- 651	.04	[illegible]
4	78	654	576	.12	247 (380)
5 STD Fill	133	1046	913	.13	325 (325)
HYD Fill	133	943	- 810	.14	325 (325)
6 STD Fill	148	1482	-1334	.10	310 (310)
HYD Fill	150	1341	-1191	.11	308 (308)
7 STD Fill	125	1011	886	.12	333 (333)
HYD Fill	124	946	- 822	.13	334 (334)
8 STD Fill	142	1555	-1413	.09	316 (316)
HYD Fill	143	1413	-1270	.10	315 (315)
Relocation Alternatives					
20	83	186	103	.45	
21	9	180	- 171	.05	

100 YEAR

Measure	BEN.	COST	NET BEN.	B/C	RESIDUAL DAMAGES**
1	$ 31	$ 6[illegible]	$ [illegible]	.0[illegible]	$ 9 (427)
2	199	896	697	.22	126 (259)
3	57	862	805	.07	23 (401)
4	136	835	699	.16	189 (322)
5 STD Fill	238	1357	-1119	.18	220 (220)
HYD Fill	240	1227	987	.2	218 (218)
6 STD Fill	252	1833	-1581	.14	206 (206)
HYD Fill	261	1668	-1407	.16	197 (197)
7 STD Fill	230	1208	- 978	.19	228 (228)
HYD Fill	232	1133	- 901	.20	226 (226)
8 STD Fill	253	1789	-1536	.14	205 (205)
HYD Fill	254	1754	-1500	.1[illegible]	204 (204)

500 YEAR

Measure	BEN.	COST	NET BEN.	B/C	RESIDUAL DAMAGES*
1	$ 35	$ 730	$- 695	.05	$ 5 (423
2	236	1093	- 857	.22	89 (222
3	78	1062	- 984	.07	2 (386
4	163	1121	- 958	.15	162 (295
5 STD Fill	292	1563	-1271	.19	166 (166
HYD Fill	297	1513	-1216	.20	161 (161
6 STD Fill	317	2119	-1802	.15	141 (141
HYD Fill	327	1964	-1637	.17	131 (131
7 STD Fill	287	1395	-1108	.21	171 (171
HYD Fill	290	1313	-1023	.22	168 (168
8 STD Fill	315	2005	-1690	.16	143 (143
HYD Fill	318	1965	-1647	.16	140 (140
Recreation Alternative					
Measure 15	56	48	+ 8	1.17	

* 1973 Flood was estimated to have had a 30 Year frequency.
** First number shown represents remaining damages to area(s) protected by measure while figures in
( ) Reflects total remaining damages in project area including the first number.

TABLE H-29

FIRST ITERATION
ANNUAL ECONOMIC BENEFITS DUE TO
REDUCTION IN MISSISSIPPI RIVER FLOOD DAMAGES
(OCTOBER 1982 DOLLARS)

Measure		Mississippi River/Gabouri Creek Protection	Residential	Commercial	Agricultural	Total
1		30/50 yr.	$ 2,000	$ 2,000	------	$ 4,000
		100 yr./100 yr.	5,000	4,000	------	9,000
		UDF/SPF	8,000	5,000	------	13,000
2		30/50 yr.	15,000	86,000	------	101,000
		100 yr./100 yr.	28,000	150,000	------	178,000
		UDF/SPF	37,000	178,000	------	215,000
3		30/50 yr.	12,000	9,000	------	21,000
		100 yr./100 yr.	25,000	21,000	------	46,000
		UDF/SPF	36,000	30,000	------	66,000
4		30/50 yr.	12,000	52,000	------	64,000
		100 yr./100 yr.	24,000	95,000	------	119,000
		UDF/SPF	33,000	113,000	------	146,000
5	STD*	30 yr.***	25,000	94,000	$11,000	130,000
	FILL	100 yr.	52,000	171,000	11,000	234,000
		UDF	72,000	208,000	8,000	288,000
	HYD**	30 yr.	25,000	94,000	11,000	130,000
	FILL	100 yr.	52,000	171,000	13,000	236,000
		UDF	72,000	208,000	13,000	293,000
6	STD	30 yr.	28,000	97,000	23,000	148,000
	FILL	100 yr.	58,000	177,000	17,000	252,000
		UDF	82,000	216,000	19,000	317,000
	HYD	30 yr.	28,000	97,000	25,000	150,000
	FILL	100 yr.	58,000	176,000	27,000	261,000
		UDF	82,000	216,000	29,000	327,000

* Standard Compacted earth levee
** Dredged, hydraulically placed levee fill
***30-Year frequency equivalant to the 1973 flood.

TABLE H-29 (Cont'd)

FIRST ITERATION
ANNUAL ECONOMIC BENEFITS DUE TO
REDUCTION IN MISSISSIPPI RIVER FLOOD DAMAGES
(OCTOBER 1982 DOLLARS)

Measure		River/Creek Protection	Residential	Commercial	Agricultural	Total
7	STD	30 yr.	$25,000	$ 94,000	$ 3,000	$122,000
	FILL	100 yr.	52,000	171,000	3,000	226,000
		UDF	72,000	208,000	3,000	283,000
	HYD	30 yr.	25,000	94,000	2,000	121,000
	FILL	100 yr.	52,000	171,000	5,000	228,000
		UDF	72,000	208,000	6,000	286,000
8	STD	30 yr.	27,000	97,000	18,000	142,000
	FILL	100 yr.	58,000	176,000	19,000	253,000
		UDF	82,000	216,000	17,000	315,000
	HYD	30 yr.	27,000	97,000	19,000	143,000
	FILL	100 yr.	58,000	176,000	20,000	254,000
		UDF	82,000	216,000	20,000	318,000
20			17,000	42,000	------	59,000
21			7,000	1,000	------	8,000

TABLE H 30

FIRST ITERATION
ANNUAL ECONOMIC BENEFITS DUE TO
REDUCTION IN TRIBUTARY FLOOD DAMAGES
(October 1982 Dollars)

		NORTH GABOURI CREEK			SOUTH GABOURI CREEK			
Measure	River/Creek Protection	Residential	Commercial	Total	Residential	Commercial	Total	Tributaries Total (Rounded)
1	30 yr./50 yr.	------	------	------	$ 199	$22,322	$22,521	$23,000
	100 yr./100 yr.	------	------	------	171	22,322	22,493	22,000
	UDF/SPF	------	------	------	171	22,322	22,493	22,000
2	30 yr./50 yr.	$ 3,518	$10,632	14,150	1,957	763	2,720	17,000
	100 yr./100 yr.	4,511	12,077	16,588	1,947	1,722	3,669	21,000
	UDF/SPF	4,511	12,077	16,588	1,857	1,728	3,585	21,000
3	30 yr./50 yr.	6,797	985	7,782	------	------	------	8,000
	100 yr./100 yr.	9,124	1,731	10,855	------	------	------	11,000
	UDF/SPF	10,043	1,906	11,949	------	------	------	12,000
4	30 yr./50 yr.	3,515	10,629	14,144	0	0	0	14,000
	100 yr./100 yr.	4,511	12,077	16,588	0	0	0	17,000
	UDF/SPF	4,510	12,077	16,587	0	0	0	17,000
5 STD*	30 yr.	------	------	------	1,796	763	2,559	3,000
FILL	100 yr.	------	------	------	2,241	1,722	3,963	4,000
	UDF	------	------	------	2,252	1,728	3,980	4,000
HYD**	30 yr.	------	------	------	1,796	763	2,559	3,000
FILL	100 yr.	------	------	------	2,241	1,722	3,963	4,000
	UDF	------	------	------	2,252	1,728	3,980	4,000
6 STD	30 yr.	------	------	------	------	------	------	------
FILL	100 yr.	------	------	------	------	------	------	------
	UDF	------	------	------	------	------	------	------
HYD	30 yr.***	------	------	------	------	------	------	------
FILL	100 yr.	------	------	------	------	------	------	------
	UDF	------	------	------	------	------	------	------

TABLE H 30 (Cont'd)

FIRST ITERATION
ANNUAL ECONOMIC BENEFITS DUE TO
REDUCTION IN TRIBUTARY FLOOD DAMAGES
(October 1982 Dollars)

		NORTH GABOURI CREEK			SOUTH GABOURI CREEK			
Measure	River/Creek Protection	Residential	Commercial	Total	Residential	Commercial	Total	Tributaries Total (Rounded)
7 STD	30 yr.	------	------	------	1,796	763	2,559	$3,000
FILL	100 yr.	------	------	------	2,241	1,722	3,963	4,000
	UDF	------	------	------	2,252	1,728	3,980	4,000
HYD	30 yr.	------	------	------	1,796	763	2,559	3,000
FILL	100 yr.	------	------	------	2,241	1,722	3,963	4,000
	UDF	------	------	------	2,252	1,728	3,980	4,000
8 STD	30 yr.	------	------	------	------	------	------	------
FILL	100 yr.	------	------	------	------	------	------	------
	UDF	------	------	------	------	------	------	------
HYD	30 yr.	------	------	------	------	------	------	------
FILL	100 yr.	------	------	------	------	------	------	------
	UDF	------	------	------	------	------	------	------
20		4,943	5,033	9,976	14,477	0	14,477	24,000
21		375	52	427	55	0	55	500

* Standard compacted earth levee.
** Dredged, hydraulically placed levee fill.
*** 1973 Flood was estimated to have had a 30 year frequency.

TABLE H-31

FIRST ITERATION
SUMMARY OF ANNUAL ECONOMIC BENEFITS
(October 1982 Dollars)

Measure		River/Creek Protection	Mississippi River Total	North Gabouri Creek Total	South Gabouri Creek Total	Total
1		30 yr./50 yr.	$ 4,000	------	$23,000	$ 27,000
		100 yr./100 yr.	9,000	------	22,000	31,000
		UDF/SPF	13,000	------	22,000	35,000
2		30 yr./50 yr.	101,000	$14,000	3,000	118,000
		100 yr./100 yr.	178,000	17,000	4,000	199,000
		UDF/SPF	215,000	17,000	4,000	236,000
3		30 yr./50 yr.	21,000	8,000	------	29,000
		100 yr./100 yr.	46,000	11,000	------	57,000
		UDF/SPF	66,000	12,000	------	78,000
4		30 yr./50 yr.	64,000	14,000	0	78,000
		100 yr./100 yr.	119,000	17,000	0	136,000
		UDF/SPF	146,000	17,000	0	163,000
5	STD*	30 yr.***	130,000	------	3,000	133,000
	FILL**	100 yr.	234,000	------	4,000	238,000
		UDF	288,000	------	4,000	292,000
	HYD	30 yr.	130,000	------	3,000	133,000
	FILL	100 yr.	236,000	------	4,000	240,000
		UDF	293,000	------	4,000	297,000
6	STD	30 yr.	148,000	------	------	148,000
	FILL	100 yr.	252,000	------	------	252,000
		UDF	317,000	------	------	317,000
	HYD	30 yr.	150,000	------	------	150,000
	FILL	100 yr.	261,000	------	------	261,000
		UDF	327,000	------	------	327,000

TABLE H-31 (Cont'd)

FIRST ITERATION
SUMMARY OF ANNUAL ECONOMIC BENEFITS
(October 1982 Dollars)

Measure		River/Creek Protection	Mississippi River Total	North Gabouri Creek Total	South Gabouri Creek Total	Total
7	STD	30 yr.	$122,000	--	$ 3,000	$125,000
	FILL	100 yr.	226,000	--	4,000	230,000
		UDF	283,000	--	4,000	287,000
	HYD	30 yr.	121,000	--	3,000	124,000
	FILL	100 yr.	228,000	--	4,000	232,000
		UDF	286,000	--	4,000	290,000
8	STD	30 yr.	142,000	--		142,000
	FILL	100 yr.	253,000	--		253,000
		UDF	315,000	--		315,000
	HYD	30 yr.	143,000	--		143,000
	FILL	100 yr.	254,000	--		254,000
		UDF	318,000	--		318,000
20			59,000	10,000	[illegible]	83,000
21			8,177	427	[illegible]	9,000

* Standard compacted earth levee
** Dredged, hydraulically placed levee fill.
*** 1973 Flood was estimated to have had a 30-year frequency.

Agricultural benefits were calculated based on preliminary alignments of levee measures and an average dollar savings per acre protected. This was done in order to allow some comparison between measures. Damages due to ponding conditions when Mississippi River stages were high were ignored during this iteration.

Presented below is a brief description of Measures 1 through 8, 20 and 21. Descriptions of measures numbered between 8 and 20 can be found in 2nd iteration discussions with the exception of Measure 14 and Measure 15. Measure 15 was a first iteration maximum recreation plan and Measure 14 was a number set aside to which a solution or measure was never applied.

a. Measure 1.

Measure 1 protects area 1 or the areas south of South Gabouri Creek. (See Figure H-1 above.) TABLE H-27 shows that Area 1 suffers more damages from South Gabouri Creek than it does from Mississippi River flooding. Commercial damages are reduced significantly by Measure 1 primarily because the structures are located within the reach of the creek protected by the levee measure. Residential damages are not significantly reduced by this measure because the residential property damaged by South Gabouri Creek is located upstream of the limits of the flank levee. TABLE H-28 shows the benefits of Measure 1 for three levels of protection studied and also notes project area remaining damages.

b. Measure 2.

Measure 2 protects Area 2 from Mississippi and North and South Gabouri Creek flooding. TABLE H-27 shows that the majority of the damages to Area 2 are commercial damages to 75 structures. These damages make up almost 50 percent of the total average annual damages in the entire project area. This area includes the central business district of Ste. Genevieve. Examination of TABLES H-30 and H-31 also indicates that very little protection is provided by Measure 2 against flooding from South Gabouri Creek while considerable success in reducing damages from the Mississippi River and North Gabouri Creek would be achieved through implementing Measure 2. Benefits and remaining damages are shown on TABLE H-28.

c. Measure 3.

Measure 3 protects Area 3 from Mississippi River flooding and from North Gabouri Creek flooding. TABLE H-27 shows that damages to Area 3 occur primarily from Mississippi River flooding. The number of commercial structures damaged are greater in Area 3 than in Area 1 but are much less than in Area 2. Residential damages exceed commercial damages. The measure seems to reduce damages significantly whether the flood comes from the Mississippi or North Gabouri Creek. TABLE H-28 shows the benefits and remaining damages associated with the levels of protection studied.

d. Measure 4.

Measure 4, as did Measure 2, protects the central business district of Ste. Genevieve. Measure 4, however, leaves many more structures unprotected and in general provides less protection than Measure 2. Implementation also causes more removal of structures than Measure 2. TABLE H-28 shows the benefits and remaining damages associated with the levels of protection studied.

e. Measures 5 and 7.

Measures 5 and 7 protect Areas 2 and 3 from Mississippi River flooding and provide some protection to Area 2 against flooding from South Gabouri Creek. The difference in each measure is in the amount of agricultural area protected from inundation. Measure 7 would provide a greater ponding area than Measure 5. However, at this first iteration stage of study development, no consideration was given to frequency of ponding for these two measures. Flooding of North Gabouri Creek would remain unchanged. TABLE H-28 shows the benefits and remaining damages associated with 30, 100, and 500-year levels of protection.

f. Measures 6 and 8.

Measures 6 and 8 protect Areas 1, 2, and 3 from flooding by the Mississippi River. Flooding along North and South Gabouri Creeks would remain unchanged. The only difference between these two measures is in the amount of agricultural area protected from inundation. Measure 6 would provide a greater ponding area than Measure 8. At this first iteration stage of study development, no consideration was given to frequency of ponding for these measures. TABLE H-28 shows the benefits and remaining damages associated with 30, 100, and 500-year levels of protection.

g. Measures 20 and 21.

Measure 20 included only structures that are flooded above the first floor by the 10 year frequency flood on the Mississippi River or on either creek. Measure 21 addressed only 16 historic structures that would have been flooded by surface water during the April 1973 flood if no emergency levee had been provided. This flooding could be above or below the first floor level. The benefits associated with these two measures are simply a summation of all average annual damages associated with each structure included in the measure. All structures considered were scheduled to be either removed or relocated and therefore would not be subject to damage under these proposals. At this first iteration

stage of study development no computations were made to account for deductions for insurance premiums or deductables, nor were additions of savings associated with insurance administrative costs or other allowable benefits included in the analysis of these two measures. TABLE H-28 shows the benefits and remaining damages associated with these two measures.

4.2.2 Second Iteration

Measure 6 was found to be most desirable by local interests. Second iteration measures included three modifications of Measure 6 (Measures 9, 10, and 11), and the development of additional structural and nonstructural measures (12, 13, 18, 19, 22) that addressed flooding on North and South Gabouri Creeks. These additional measures included channel widening, bridge modifications, clearing and snagging, and low levees as well as relocation and elevation of structures.

This stage of the study also determined a significant number of errors in surveyed first floor elevations. TABLES H-17 and H-20 thru H-22 summarize the existing damages to residential and commercial structures by event and average annual damages based on revised structure elevations. Comparison of TABLE H-27 with TABLE H-17 reveals that six (6) additional structures were damaged as a result of elevation changes.

In addition an increase of $39,000 in average annual damages occurred, primarily in Area 2, due to Mississippi River and South Gabouri Creek flooding. Of particular note are the damages associated with one structure. This structure is a large warehouse whose floor elevation was lowered 2.8 feet when elevations were revised. The resulting average annual damages to this structure increased almost $70,000, which was composed of $41,000 additional damages from Mississippi River flooding and $29,000 additional from South Gabouri Creek flooding. The building was listed as a hardware goods store for damage computations following a visit to the building. It was observed that two-thirds of the building was basically vacant. The area that could be seen had a raised level (4 feet above normal floor) which ran along an outside wall and generally hardware goods and some unfinished window moldings were stored there. The normal floor level appeared to be used sparcely. The remaining one-third of the building area was at the higher raised level and contained finished window goods. The other end of the building was rented to a company that made modular agricultural stock buildings. Because water would not begin to cause much damage until it reached the rai ed level, a damage code was selected that computed a lessor damage value for water levels between the first floor level and 4 feet above it. Total average annual damages to this one structure were $120,000. Almost 25 percent of the total damages in the Ste. Genevieve study area can be attributed to this one building.

In all, 85 building elevations were changed and 2 new structures were added during this stage of report development. The first floor elevations of some structures were actually lowered 3 to 4 feet. However, others were raised. The resulting change in average annual damage was from $420,000 to $459,000, with an additional 6 structures being damaged. This comparison can be made by referring to TABLES H-27 and H-17.

a. Measures 9, 10, and 11.

Measures 9, 10, and 11 are levee measures which, as shown on PLATES A-11, A-12, and A-13 in Appendix A, Plan Formulation, protect areas 1,2, and 3 from flooding from the Mississippi River. Levee alinements for Measures 9 and 10 do not protect a major sewage lagoon nor do they provide additional protection to the existing agricultural Levee District #2. Both Measures 10 and 11 protect Area 500 which borders Highway 61 on the south end of the project area and is just outside the city limits. Measure 11 includes protecting the sewage lagoon, as well as a portion of the land within the levee District #2. An existing agricultural levee included within Measure 11 would be degraded to provide additional ponding area. These measures do not address damages from flooding by the two Gabouri Creeks. Also Ponding will take place at high Mississippi River stages. The frequency of ponding elevations was considered to be the same for Measures 9, 10, and 11 because even though

available ponding area changes do occur under each measure, a corresponding change in pump station size also occurred. Damages to residential and commercial structures due to ponding only have been calculated to be $3,300. Agricultural damages from ponding were computed as $120 per acre with 143 acres damaged annually due to ponding for a total of $17,200. Damages and benefits for these measures are shown on TABLES H-32, H-33, and H-34.

b. Measures 12 and 13.

Measures 12 and 13 are channel widening and small levee measures developed to reduce damages from flooding due to rainfall within the North and South Gabouri Creek watersheds. Measure 12 addresses flooding on South Gabouri Creek. A 3 foot levee on the left bank of South Gabouri Creek between mile 1.35 and 1.664 would provide 25-year protection to structures in Area 2 between those river miles. Measure 13 addresses flooding on North Gabouri Creek. A 5 foot levee on the right bank of North Gabouri Creek between Mile 1.329 and 1.509 would provide 500 year protection to structures in Area 2 between those river miles. Measure 12 also includes four (4) bridge replacements. Measure 13 similarly includes two (2) bridge replacements. These "bridges" are basically small bank level crossings generally to private properties. No advance replacement benefits or discounting of remaining benefits have been included in the benefit analysis for these bridges baecause of their small costs and indeterminent remaining life. A 25-year frequency flood

TABLE H-32
SECOND ITERATION
AVERAGE ANNUAL DAMAGES/BENEFITS
WITH AND WITHOUT MEASURE 9

	Damages Without Measure 9		Damages After Implementation of Measure 9								
	Total		Mississsippi River		North Gabouri		South Gabouri		Total		
Urban Area	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	Average Annual Benefits
I Commercial	8	$ 23,000	0	0	-	-	3	$18,000	3	$ 18,000	$ 5,000
Residential	63	18,000	0	0	-	-	16	9,000	16	9,000	9,000
II Commercial	76	259,000	0	0	33	$11,000	5	31,000	38	42,000	217,000
Residential	163	65,000	0	0	60	6,000	60	14,000	120	20,000	45,000
III Commercial	20	30,000	0	0	9	2,000	-	-	9	2,000	28,000
Residential	163	51,000	0	0	108	11,000	-	-	108	11,000	40,000
500	16	13,000	16	$13,000	-	-	-	-	16	13,000	0
Total											
Commercial	120	$325,000	16	$13,000	42	$13,000	8	$49,000	66	$ 75,000	$250,000
Residential	389	134,000	0	0	168	17,000	76	23,000	244	40,000	94,000
TOTAL URBAN	509	$459,000	16	$13,000	210	$30,000	84	$72,000	310	$115,000	$344,000
AGRICULTUTAL		25,700								4,800	20,900
Less Damages From Ponding											
URBAN											
Commercial		0								3,000	-3,000
Residential		0								300	-300
AGRICULTURAL		0								17,200	-17,200
TOTAL DAMAGES		$484,700								$140,300	
TOTAL BENEFITS										$344,400	

TABLE H 33
SECOND ITERATION
AVERAGE ANNUAL DAMAGES/BENEFITS
WITH AND WITHOUT MEASURE 10

	Damages Without Measure 10		Damages After Implementation of Measure 10								
	Total		Mississsippi River		North Gabouri		South Gabouri		Total		
Urban Area	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	Average Annual Benefits
I Commercial	8	$ 23,000	0	0	-	-	3	$18,000	3	$ 18,000	$ 5,000
Residential	63	18,000	0	0	-	-	16	9,000	16	9,000	9,000
II Commercial	76	259,000	0	0	33	$11,000	5	31,000	38	42,000	217,000
Residential	163	65,000	0	0	60	6,000	60	14,000	120	20,000	45,000
III Commercial	20	30,000	0	0	9	2,000	-	-	9	2,000	28,000
Residential	163	51,000	0	0	108	11,000	-	-	108	11,000	40,000
500	16	13 000		-		-	-				13,000
Total Commercial	120	$325,000	0	0	42	$13,000	8	$49,000	50	$ 62,000	$263,000
Residential	389	134,000	0	0	168	17,000	76	23,000	244	40,000	94,000
TOTAL URBAN	509	$459,000	0	0	210	$30,000	84	$72,000	294	$102,000	$357,000
AGRICULTURAL		25,000								4,400	20,600
Less Damages From Ponding URBAN											
Commercial		0								3,000	-3,000
Residential		0								300	-300
AGRICULTURAL		0								17,2[illegible]	-17,200
TOTAL DAMAGE		$484,000								$126,900	
TOTAL BENEFITS										$357,100	

TABLE H-34
SECOND ITERATION
AVERAGE ANNUAL DAMAGES/BENEFITS
WITH AND WITHOUT MEASURE 11

	Damages Without Measure 11		Damages After Implementation of Measure 11								
	Total		Mississsippi River		North Gabouri		South Gabouri		Total		
Urban Area	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	No. Bldgs. Damaged	Remaining AAD	Average Annual Benefits
I Commercial	8	$ 23,000	0	0	-	-	3	$18,000	3	$ 18,000	$ 5,000
Residential	63	18,000	0	0	-	-	16	9,000	16	9,000	9,000
II Commercial	76	259,000	0	0	33	$11,000	5	31,000	38	42,000	217,000
Residential	163	65,000	0	0	60	6,000	60	14,000	120	20,000	45,000
III Commercial	20	30,000	0	0	9	2,000	-	-	9	2,000	28,000
Residential	163	51,000	0	0	108	11,000	-	-	108	11,000	40,000
500	16	13,000	0	0	-	-	-	-			13,000
Total											
Commercial	120	$325,000	0	0	42	$13,000	8	$49,000	50	$62,000	$263,000
Residential	389	134,000	0	0	168	17,000	76	23,000	244	40,000	94,000
TOTAL URBAN	509	$459,000	0	0	210	$30,000	84	$72,000	294	$102,000	$357,000
AGRICULTURAL		22,800								3,000	19,800
Less Damages From Ponding											
URBAN											
Commercial		0								3,000	-3,000
Residential		0								300	-300
AGRICULTURAL		0								17,200	-17,200
										$125,500	
TOTAL DAMAGES		$481,800									
TOTAL BENEFITS										$356,300	

on South Gabouri Creek would damage 32 structures (TABLE H-22) and cause $380,200 in damages ($290,000 of which would be to two commercial buildings). If measure 12 were in place, 13 residential structures and the same 2 commercial buildings would still be damaged but below the 25-year flood level. Two of the 13 residential structures would have less than 1 foot of water over their first floor. All the others would sustain damages in their basements. Damages would be reduced to approximately $161,000 ($141,000 of which would be to the two commercial buildings). Residential damages would be reduced from $90,000 to $20,000. Average annual damages due to flooding on South Gabouri Creek would be reduced from approximately $72,000 to $19,000 with implementation of measure 12. (See TABLE H-35).

A 25-year frequency flood on North Gabouri Creek would damage a total of 39 buildings (TABLE H-21) and cause approximately $159,000 in damages, $82,000 of which would be to six commercial buildings. If Measure 13 were in place, seven residential buildings would continue to be damaged although to a lesser degree at the 25-year event. There would not be any damage to the commercial buildings and six of the residential structures would be damaged in the basements only. Average annual residential damages would be reduced to $4,100 and commercial buildings would be damaged at $600 annually (See TABLE H-36). Total residual damages from North Gabouri Creek flooding would thus be $4,700.

TABLE H-35
SECOND ITERATION
SOUTH GABOURI CREEK
MEASURE 12
(Channel Widening with Levee - Left Bank)

	Damages Without Measure 12			Damages After Implementation of Measure 12		
				Channel plus Levee		
Area	AAD Damage	SPF No. of Struct. Damaged	Frequency Year First Damaged	AAD Damage	SPF No. of Struct. Damaged	Frequency Year First Damaged
I Commercial	$18,000	3	5	$ 3,000	3	25
Residential	9,000	16	2	3,000	16	2
II Commercial	31,000	5	10	11,000	5	25
Residential	14,000	60	2	2,000	53	10
	$72,000	84		$19,000	77	

Decrease in number of Structures Damaged	7
Total Benefits	$ 53,000
Residual Damages*	$406,000

*Residual damages include the entire study area, not just South Gabouri Creek.

TABLE H-36
SECOND ITERATION
NORTH GABOURI CREEK
MEASURE 13
(Channel Widening with Levee - Right Bank)

	Damages Without Measure 12			Damages After Implementation of Measure 12		
				Channel plus Levee		
Area	AAD Damage	SPF No. of Struct. Damaged	Frequency Year First Damaged	AAD Damage	SPF No. of Struct. Damaged	Frequency Year First Damaged
II Commercial	$11,000	33	10	$ 500	10	500
Residential	6,000	60	10	500	38	10
III Commercial	2,000	9	25	100	8	2,000
Residential	11,000	108	2	3,600	69	5
	$30,000	210		$4,700	125	

Decrease in number of Structures Damaged	85
Total Benefits	$ 25,300
Residual Damages*	$433,700

*Residual damages include the entire study area, not just North Gabouri Creek.

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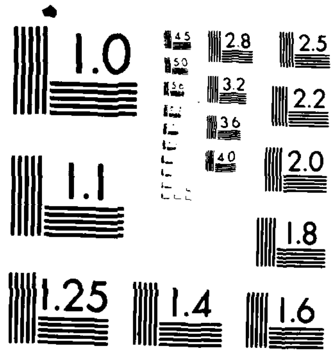

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TABLES H-35 and H-36 show the benefits of these two measures from the standpoint of reducing damages to residential and commercial structures only. The analysis assumed a non-flooding Mississippi River. As a result there was no ponding or backwater effect. The overall results of these assumptions, however, were minimal.

c. Measures 18 and 19.

Measures 18 and 19 addressed clearing and snagging along South and North Gabouri Creeks. Clearing and snagging involves clearing debris and gravel bars out of the channel bottom, and clearing brush and trees from the channel bottom and sides up to the top of banks. Measure 18 provides for clearing and snagging on South Gabouri Creek from just upstream of the Missouri Illinois Railroad crossing near Main Street (mile 1.7) to a point behind the Knights of Columbus hall (Mile 2.1). Measure 19 provides for clearing and snagging on North Gabouri Creek from the St. Louis and San Francisco Railroad crossing (mile 1.25) to Third Street (mile 1.49). Measures 18 and 19 are shown on PLATE A-14 of Appendix A, Plan Formulations. Average annual benefits and remaining damages are shown on TABLE H-37.

d. Measure 22.

Measure 22 is a nonstructural measure designed to accomplish essentially what the major levee measures would, i.e. protect the community from Mississippi River flooding. Measure 22 provides

TABLE H-37
SECOND ITERATION
SOUTH GABOURI CREEK
MEASURE 18
(Clearing & Snagging Only)

	DAMAGES WITHOUT MEASURE 18			DAMAGES WITH MEASURE 18		
Area	AAD Damages	SPF No. of Struct. Damaged	Frequency Year First Damaged	AAD Damaged	SPF No. of Struct. Damaged	Frequency Year First Damaged
I Commercial	$18,000	3	5	$17,700	3	5
Residential	9,000	16	2	8,300	16	2
II Commercial	31,000	5	10	31,000	5	10
Residential	14,000	60	2	11,200	58	2
	$72,000	84		$68,200	82	

Decrease in number of structures damaged	2
Measure 18 Benefits	$3,800
Study Area Residual Damages	$455,200

SECOND ITERATION
NORTH GABOURI CREEK
MEASURE 19
(Clearing & Snagging Only)

	DAMAGES WITHOUT MEASURE 19			DAMAGES WITH MEASURE 19		
Area	AAD Damages	SPF No. of Struct. Damaged	Frequency Year First Damaged	AAD Damaged	SPF No. of Struct. Damaged	Frequency Year First Damaged
II Commercial	$11,000	33	10	$ 5,800	32	25
Residential	6,000	60	10	3,600	59	10
III Commercial	2,000	9	25	1,200	9	25
Residential	11,000	108	2	9,400	106	2
	$30,000	210		$20,000	206	

Decrease in number of structures damaged	4
Measure 19 Benefits	$ 10,000
Study Area Residual Damages	$449,000

protection from the 25-year floods on North and South Gabouri Creek with some residual damages in the basements of buildings. The features of this measure on South Gabouri Creek include removal of 12 structures and flood proofing one commercial building. This reduces damages not only from South Gabouri Creek as shown on TABLE H-38, but also is beneficial in reducing damages occurring from Mississippi River flooding. The features of measure 22 on North Gabouri Creek include a levee between mile 1.329 to 1.509 (The same levee provided under Measure 13), 5 structure removals, and raising of one historic home 3 feet. The total reduction in damages are $97,000 as shown on TABLE H-38. Approximately $38,000 reduction in AAD are achieved on the Mississippi River flooding and $59,000 in damages on North and South Gabouri Creek is prevented. $361,000 in residual damages still remain if measure 22 is adopted. The 17 removals (relocations) mentioned above account for 16 percent of the $97,000 total benefits. Floodproofing of 2 buildings account for another 58 percent of the damage reduction and the small levee in North Gabouri Creek accounted for the remaining 26 percent of the benefits for this measure. Further examination of the component of this measure indicated that relocation of 13 buildings and 4 trailers (17 total) was not incrementally justified. A benefit to cost ratio computation for this relocation measure was 0.29 and included an accounting for insurance deductables, home owner policy costs, reduction of emergency evacuation costs, and insurance industry administrative costs. The features of this measure which were carried forward as Plan 4 were the floodproofing of one structure and the levee on the south side of North Gabouri Creek.

TABLE H-38
SECOND ITERATION
SOUTH GABOURI CREEK
MEASURE 22

Area	DAMAGES WITHOUT MEASURE 22 AAD Damages	SPF No. of Struct. Damaged	Frequency Year First Damaged	DAMAGES WITH MEASURE 22 AAD Damaged	SPF No. of Struct. Damaged	Frequency Year First Damaged
I Commercial	$18,000	3	5	$18,000	3	5
Residential	9,000	16	2	1,600	11	2
II Commercial	31,000	5	10	3,600	5	100
Residential	14,000	60	2	8,100	53	2
	$72,000	84		$31,300	72	

Decrease in number of structures damaged	12
Measure 22 Benefits S. GAB. Creek	$40,700
Measure 22 Benefits Miss.River	$27,800
Study Area Residual Damages	$390,500

SECOND ITERATION
NORTH GABOURI CREEK
with Levee - Right Bank
Mile 1.329 to 1.509
Measure 22

Area	DAMAGES WITHOUT LEVEE - RIGHT BANK AAD Damages	SPF No. of Struct. Damaged	Frequency Year First Damaged	DAMAGES WITH LEVEE - RIGHT BANK AAD Damaged	SPF No. of Struct. Damaged	Frequency Year First Damaged
II Commercial	$11,000	33	10	$ 1,200	33	500
Residential	6,000	60	10	1,200	60	10
III Commercial	$ 2,000	9	25	1,500	8	50
Residential	11,000	108	2	8,000	103	5
	$30,000	210		$11,900	204	

Decrease in number of structures damaged	6
Measure 22 Benefits	$ 18,100
Measure 22 Benefits Miss. River	$ 10,200
Study Area Residual Damages	$430,700

TOTAL MEASURE 22

TOTAL Decrease in number of structures damaged	18
TOTAL Measure 22 Benefits	$ 96,800
TOTAL Study Area Residual Damages	$362,200

A summary of the economic performance of these second iteration measures is shown on TABLE H-39.

4.3 DEVELOPMENT OF PLANS

4.3.1 Final Plans Considered.

The final set of plans for flood damage reduction and recreation in Ste. Genevieve were formulated by combining second iteration measures. Each plan combination is discussed below.

a. PLAN 1 is a combination of Measures 9, 12, 13, and 16. This plan provides 500-year protection from Mississippi River flooding to all areas except Area 500, and a minimum of 25-year protection on North and South Gabouri Creek with minor residual damages. The plan also includes a recreation measure (16) with the Mississippi River levee and the measures on the tributary streams. Recreation features include hiking and bicycling trails, picnic tables and softball field facilities on land purchased for the flood protection project features. Plan 1 is shown on PLATE 4, Volume 1, Main Report. TABLE H-40 shows the benefits and remaining damages associated with Plan 1.

b. PLAN 2 is a combination of Measures 10, 12, 13, and 16. This plan provides the same protection as Plan 1, but also includes Area 500

TABLE H-39
SECOND ITERATION
ECONOMIC PERFORMANCE SUMMARY
(In 1,000 of October 1982 dollars)

	Benefit Categories								
Measure	Urban	Agri-cultural	Ecological	Recreation	Total Benefit	Cost	Net Benefit	Benefit-Cost Ratio	Residual Damages
9	$340.7	$3.7	$ 9.0		$353.4	$2,513	$-2,160	0.14	$140
10	353.7	3.4	10.6		367.7	2,659	-2,291	0.14	127
11	353.7	2.6	12.3		368.6	2,540	-2,171	0.15	126
12	53				53	238	- 185	0.22	406
13	25.3				25.3	124	- 99	0.20	434
16				45.2	45.2	19	+ 26	2.4	459
18	3.8				3.8	2	+ 1.8	1.9	455
19	10				10	1.6	+ 8.4	6.3	449
22	96.8				96.8	88	+ 8.8	1.10	362

in the Mississippi River levee protection. Plan 2 is shown on PLATE 5, Volume 1, Main Report. TABLE H-40 shows damages and benefits associated with Plan 2.

c. PLAN 3 provides the same protection as Plan 2 and in addition, includes protection of the Ste. Genevieve sewage lagoons. Plan 3 is a combination of Measures 11, 12, 13, and 16. It is shown on PLATE 6, Volume 1, Main Report. Benefits and remaining damages are show on TABLE H-40.

d. Plan 4 is a combination of measures 18, 19, and selected features from measure 22. It consists of clearing and snagging on North and South Gabouri Creeks, floodproofing a commercial building, and constructing a levee on North Gabouri Creek. It is shown on PLATE 7, Volume 1, Main Report. This plan did not include a recreation feature. Benefits and remaining damages are shown on TABLE H-40.

4.3.2 "NED" Analysis.

Plan 4 has been selected as the "NED" Plan. This title is actually a misnomer because it is the only combination of measures which produced a positive benefit/cost ratio. Plan 4 is a combination of measures 18, 19, and selected features from measure 22. Measures 18 and 19 yielded positive benefit to cost ratios. Floodproofing a commercial building and constructing the levee on North Gabouri Creek were the only 2 features

TABLE H-40
SUMMARY OF FINAL PLANS
DAMAGES AND BENEFITS BY CATEGORY

	Urban						
AVERAGE ANNUAL DAMAGES:	Residential	Commercial	Total	Agricultural	Recreation	Ecological Benefits	Total
Total Existing	$134,000	$325,000	$ 459,000	$25,700			$484,70[illegible]
Total Future Without	160,000	325,000	485,000	30,100			515,10[illegible]
Total Future With:							
Recommended Plan	10,800	26,200	37,000	25,800			62,80[illegible]
Plan 2	10,800	14,000	24,800	26,100			50,90[illegible]
Plan 3	10,800	14,000	24,800	27,100			51,90[illegible]
PLan 4	149,600	286,200	435,800	30,100			465,90[illegible]
AVERAGE ANNUAL BENEFITS:							
Recommended Plan	149,200	298,800	448,000	4,300	45,200	9,000	506,500
Plan 2	149,200	311,000	460,200	4,000	45,200	10,600	520,000
Plan 3	149,200	311,000	460,200	3,000	45,200	12,300	520,700
Plan 4	10,400	38,800	49,200	-0-	-0-	-0-	49,20[illegible]

found to be incrementally justified and thus carried forward from measure 22. The total benefits of this plan are $49,200. It has a benefit to cost ratio of 1.4 and there are $465,900 residual damages to the study area. All other plans have benefit to cost ratios less than one and negative net benefits.

4.4 RECOMMENDED PLAN

Plan 1 was selected as the recommended Plan. It is the Plan desired by the City of Ste. Genevieve and the Ste. Genevieve County Levee District #3. It provides 500 year urban design flood protection from Mississippi River flooding and a minimum of 25 year protection from flooding on North and South Gabouri Creeks with essentially minor flooding in basements. Total benefits and remaining damages are $506,500 and $62,800, respectively.

4.4.1 Economic Performance.

TABLES H-40, H-41, and H-42 show damages and residual damages, benefits, net benefits, annual costs and benefit to cost ratios for the four plans considered in the final array including the recommended Plan 1. TABLE H-43 shows existing damages and with project event damages which is a measure of the economic performance effectiveness of the recommended plan in reducing flood damages.

TABLE H-41
SUMMARY COSTS BY PLANS
(In 1,000 of OCTOBER 1982 DOLLARS)

	Flood Damage Reduction Cost	Recreation Cost	First Cost	Interest During Construction	Total Project Cost	Annual Int. & Amort. @ 7 7/8%	Annual Operation & Maint.	Annual Replacement Cost	Total Average Annual Cost
Plan 1	$31,350	$150	$31,500	$6,005	$37,505	$2,955	$74	$5	$3,034
Plan 2	32,850	150	33,000	6,323	39,323	3,098	83	6	3,187
Plan 3	31,550	150	31,700	6,092	37,792	2,978	83	5	3,066
Plan 4	410	-0-	410	-0-	410	32	3	0.3	35

TABLE H-42

ECONOMIC PERFORMANCE OF PLANS

(OCTOBER 1982 PRICE LEVEL)

	Plan 1	Plan 2	Plan 3	Plan 4
Total Annual Cost	$ 3,034,000	$ 3,187,000	$ 3,066,000	$ 35,000
Total Annual Benefits	506,500	520,000	520,700	49,200
Net Benefits	-2,527,500	-2,667,000	-2,545,300	14,200
Benefit/Cost Ratio	0.17	0.16	0.17	1.4
Residual Damages	62,800	50,900	51,900	465,900

TABLE H-43
RECOMMENDED PLAN
FLOOD CONTROL PERFORMANCE*
(OCTOBER 1982 PRICE LEVEL)

Flood Event in Years	Event Damages without Recommended Plan	Event Damages with Recommended Plan	Event Benefits	Percent Damage Reduction
1	$ 0	$ 0	$ 0	0
2	8,600	1,900	6,700	77.9%
5	88,800	10,200	78,600	88.5%
10	1,053,500	55,900	997,600	94.7%
25	3,474,200	179,000	3,295,200	94.8%
25**	3,474,200	297,200	3,177,000	91.4%
50	5,827,200	512,800	5,314,400	91.2%
100	8,026,500	685,500	7,341,000	91.5%
500	12,102,700	1,090,100	11,012,600	91.0%
500**	12,102,700	1,299,400	10,803,300	89.3%

* This table includes only residential and commercial damages and excludes agricultural damages and damages due to ponding.

** Including overtopping of short levee's designed to 25 years on South Gabouri and 500 year frequency on North Gabouri Creek.

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

APPENDIX I

ENDANGERED SPECIES COORDINATION

STE. GENEVIEVE, MISSOURI

APPENDIX I

ENDANGERED SPECIES COORDINATION

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BH

-BH

United States Department of the Interior

FISH AND WILDLIFE SERVICE
2701 Rockcreek Parkway, Suite 106
North Kansas City, Missouri 64117

KANSAS CITY AREA OFFICE
816/374-6166

ECOLOGICAL SERVICES
816/374-5951

May 3, 1982

Colonel Robert J. Dacey
District Engineer
St. Louis Dist., Corps of Engineers
210 N. Tucker Blvd.
St. Louis, Missouri 63101

Dear Colonel Dacey:

This is in response to your agency's request for a list of endangered species, regarding the proposed Historic Saint Genevieve Flood Control Project in Ste. Genevieve County, Missouri.

In accordance with Section 7(c) of the Endangered Species Act, as amended, we have reviewed the project information and our "Red Book of Endangered Species," and we have determined that the following listed species may occur in the project area.

Listed Species

Bald eagle (Haliaeetus leucocephalus)
Indiana bat (Myotis sodalis)

Proposed Species

None

It is the Corps of Engineers' responsibility to review the project and evaluate the possible effects on federally listed species. The determination to be made on each project is whether the proposed action "may affect or will not affect" listed threatened or endangered species. If it is determined the project "will not affect" an endangered species, no further action is necessary, and the procedure is terminated. If, however, your determination is the project "may affect," you should request formal consultation. The Area Manager, U.S. Fish and Wildlife Service, Kansas City, Missouri, has the prerogative to request your agency to formally consult on any project if deemed necessary. If there are any questions regarding the biological assessment or how it applies to the consultation process, please contact Mr. Larry Visscher, Endangered Species Coordinator, U.S. Fish and Wildlife Service, 2701 Rockcreek Parkway, Suite 106, North Kansas City, Missouri (816/374-6166).

Sincerely yours,

Tom A. Saunders

Tom A. Saunders
Area Manager

cc: R-3 (SE)
Dr. Jim D. Wilson - MDC
Planning Section - MDC

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE
30 Mar 83

SUBJECT OF CONVERSATION

Ste. Genevieve Endangered Species

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
John Brady	SLD	314-263-5711
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**
Al Balliette	USFWS	618-997-5491

SUMMARY OF CONVERSATION:

Mr. Balliette updated the endangered species list for the Ste. Genevieve Project to include:

Higgin's Eye Pearly Mussel
Lampsilis higginsi

Fat Pocketbook Pearly Mussel
Potamilus capax

Indiana Bat
Myotis sodalis

Bald Eagle
Haliaeetus leucocephalus

JTB

JOHN T. BRADY

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

U.S. G.P.O. 1982-564-036 0371

1Y/2 2 24)

June 22, 1983

Planning Division
Environmental Analysis Branch

Mr. Joseph Janecek
U.S. Fish and Wildlife Service
Rural Route 3
Box 19SA
Marion, Illinois 62959

Dear Mr. Janecek:

Attached is the biological assessment for the Flood Control Study for Historic Ste. Genevieve.

Please send me your comments.

Sincerely,

JACK F. RASMUSSEN, P.E.
Chief, Planning Division

DUNN
PD-A

HAWICKHOR
PD

RASMUSSEN
PD

BIOLOGICAL ASSESSMENT
FLOOD CONTROL STUDY FOR HISTORIC
STE. GENEVIEVE

INTRODUCTION

In response to a request from the St. Louis District, the U.S. Fish and Wildlife Service provided the following list of endangered species that may occur in the project area:

Higgin's Eye Pearly Mussel - Endangered
Lampsilis higginsi

Fat Pocketbook Pearly Mussel - Endangered
Potamilis capax

Indiana Bat - Endangered
Myotis sodalis

Bald Eagle - Endangered
Haliaeetus leucoceplialus

DESCRIPTION OF STUDY AREA

The study area consists of a portion of the Mississippi River floodplain which is primarily devoted to agricultural crop production. A few remnants of forest exist adjacent to the Mississippi river bank, the North and South Gabouri Creeks, Valley Spring Branch, and the Mississippi Slough.

Adjacent to the floodplains are the rolling Ozark hills drained by the three creeks. Most of the uplands are a patchwork of forest and pasture with forest being more extensive in the headwaters. Corp production is limited to the narrow creek floodplains.

The town itself begins on the edge of the floodplain and extends into the uplands. North and South Gabouri Creeks flow through the town.

Wildlife habitat quality varies from good to excellent in the headwaters, to fair to poor in the urban area and intensively farmed floodplain.

DESCRIPTION AND TIME PERIOD OF CONSTRUCTION

Description. This study was authorized by a resolution introduced by Congressman Park M. Banta of Missouri and adopted on 17 June 1948 by the Committee on Public Works of the United States House of Representatives. The purpose is to determine the feasibility of flood damage reduction and related improvements at Ste. Genevieve, Missouri. Ste. Genevieve is a unique historic town with many of its French colonial structures built in the 1700's, still standing and subject to flooding.

The Recommended Plan (PLAN 1) consists of the following measures (See FIGURE 1).

a. 3.2 miles of urban design levee built in the Mississippi River floodplain.

b. One (1) 650 cfs pump station.

c. Three (3) gravity drains.

d. 83 acres of borrow pits to be turned into marshes.

e. 4000 linear feet of new channel for interior drainage.

f. 1200 linear feet of new creek channel.

g. 1.83 miles of stream widening on North and South Gabouri Creek with Gabouri and/or rip-rap protection.

h. Six (6) bridge replacements.

i. 4.75 miles of foot/bicycle trails adjacent to widened creeks and on new levee.

Construction Schedule

a. Construct levee, ditches, gravity drains - October 1988-October 1990.

b. Construct pump station - October 1990-October 1992.

c. Construct channel widening and recreation measures - October 1990-October 1992.

ASSESSMENT OF POTENTIAL IMPACTS

a. Fat Pocketbook Pearly Mussel - (*Potamilis capax*). The only modern records in Missouri for this species are from two localities on the upper Mississippi River (Nordstrom *et al.*, 1977). Buchanan (1983) reports that the species has not been reported south of Saverton, Missouri since 1965. He believes that the Mississippi River south of St. Louis has become unsuitable for this species because of pollution, channelization and maintenance dredging. Therefore, there will be no impacts to this species.

b. Higgins' Eye Pearly Mussel - (*Lampsilis higginsi*). This species was formerly found in the Mississippi River (Nordstrom *et al.*, 1977). Buchanan (1983) believes that the Mississippi River south of St. Louis has become unsuitable for this species also. Therefore, there will be no impacts to this species.

c. Bald Eagle - (*Haliaeetus leucocephalus*). The bald eagle is primarily a winter visitor in the Ste. Genevieve area. They primarily occur along the Mississippi River catching fish and perching in large riparian trees. The Illinois Natural History Survey has made aerial waterfront surveys (including bald eagles) for the last ten years. In the winter of 1981-82 as many as 45 eagles were observed at one time between Crystal City, Missouri, and Chester, Illinois. There is no known important bald eagle habitat in the study area. There are no known eagle concentrations in the project area (Wilson, Personal Communication; Compton, Personal Communication).

The hydraulic dredging in the Mississippi River that will be used to obtain material to build the levee could disturb the occasional eagle that occurs in the 3 mile reach. This activity will occur periodically for 2 years. Since there are relatively few eagles that use this area, there will be no significant adverse impacts to the bald eagles.

d. Indiana Bat (*Myotis sodalis*). Potential Indiana bat summer habitat exists along the tree-lined streams in the study area as well as along the Mississippi Slough. Females and young form maternity colonies in this type of habitat between mid-May and mid-September. They average about 75 bats per kilometer of suitable habitat (Brady, In Preperation). There are no known nursery colonies in the study area.

The building of the levee will result in the loss of 1670 feet of natural stream channel and 870 feet of wooded slough, all with riparian forest. A new 1200 foot channel will be established. The easement adjacent to the new channel will be allowed to grow into riprapian forest which should take 15 to 20 years. The net effect will be a minor decrease (1340 feet) in potential Indiana bat summer habitat.

The widening of North and South Gabouri Creek will result in the loss of 4916 feet of potential Indiana bat summer habitat. The degraded water quality in South Gabouri Creek caused by mine waste discharge as well as the urban, disturbed nature of both streams lead to the conclusion that this is not important habitat.

In summary, neither of these actions will have a significant impact on the Indiana bat.

EFFORTS TO ELIMINATE ADVERSE IMPACTS ON SPECIES AND HABITAT

Clearing of trees is scheduled to take place between 15 September and 1 April. This will avoid destroying any nursery colony of Indiana bats that may be present.

LITERATURE CITED

Brady, J.T., T.H. Kunz, M.D. Tuttle, D.E. Wilson, R.L. Clawson, and R.K. LaVal. In Preparation. Indiana Bat Recovery Plan. U.S. Fish and Wildlife Service. Twin Cities, MN.

Buchanan, A. 1983. Personal Communication. Missouri Department of Conservation, Columbia, MO.

Compton, R. 1983. Personal Communication. Illinois Natural History Survey, Havana, IL.

Nordstrom, G.R., W.L. Pflieger, K.C. Sadler and W.H. Lewis. 1977. Rare and Endangered Species of Missouri. Mo. Dept. Cons. and USDA (SCS). Jefferson City, MO.

Wilson, J.H. 1983. Personal Communication. Missouri Department of Conservation. Jefferson, MO.

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20-A

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

IN REPLY REFER TO:
AH/ES
3-83-F-IL-25S

JUL 8 1983

Colonel Gary D. Beech
District Engineer
U.S. Army Engineer District
St. Louis
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Dear Colonel Beech:

This responds to your letter dated June 22, 1983, transmitting the biological assessment prepared by your staff in accordance with Section 7 of the Endangered Species Act of 1973. The assessment is in reference to the recommended plan (Plan 1) for the Flood Control Study for Historic Ste. Genevieve. This study was authorized by a resolution introduced by Congressman Park M. Banta of Missouri and adopted on June 17, 1948, by the Committee on Public Works of the United States House of Representatives.

We have reviewed the biological information and assessment provided by the St. Louis District, along with other pertinent information in our files. We have also reviewed the available literature on the local distribution of Federally listed threatened and endangered species, and we have consulted with recognized authorities with knowledge of these species and their current distribution.

After careful consideration of the information available, it is my biological opinion that the proposed project is not likely to jeopardize the continued existence of Federally listed endangered or threatened species. This biological opinion is based on the assumption that clearing of trees will be scheduled between September 15 and April 1, as indicated in the assessment. The purpose for this scheduling is to avoid destroying any nursery colony of Indiana bats (*Myotis sodalis*) that may be present.

We concur with your findings that although there are no known nursery colonies in the study area, potential Indiana bat summer habitat does exist along the tree-lined streams and Mississippi Slough. The species range during the summer colony nesting period encompasses several states. The loss of potential colony nesting habitat in the project area would not jeopardize the continued existence of the species because of the widespread summer distribution.

The Endangered Species Act states that all Federal agencies shall seek to conserve endangered and threatened species and shall utilize their authorities in furtherance of the purposes of the Act. Your agency has an excellent opportunity to enhance the project area for the Indiana

bat by limiting clearing and widening activities to one bank of Mississippi Slough and the floodplain portion of streams. This would insure that the project area has a continued supply of overmature and dead trees with exfoliating bark which provides sites for nursery colonies. We strongly recommend that you include this enhancement feature as part of the recommended plan.

Discussions with Dr. David Stansbery of Ohio State University verify your assumption that the project area section of the Mississippi River no longer provides suitable habitat for the Higgins' eye pearly mussel (Lampsilis higginsi) and the fat pocketbook pearly mussel (Potamilus capax). Based on the information available to us at this time and the lack of information which would indicate otherwise, we conclude these species are not present in the project area.

The bald eagle (Haliaeetus leucocephalus) winters along the Mississippi River in the vicinity of the project area and at times is found in relatively high numbers. We have found no information indicating that bald eagles concentrate in the project area proper for feeding, roosting, or other purposes. Based on the lack of information which would indicate otherwise, it is our conclusion that the proposed project will not affect the bald eagle.

This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended. Should this project be modified or new information indicates that endangered species may be affected, consultation should be reinitiated.

This letter provides comment only on the endangered species aspect of this project. Comments on other aspects under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) will be made under separate cover.

Sincerely yours,

James C. Gritman

James C. Gritman
Acting Regional Director

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

APPENDIX J

U. S. FISH AND WILDLIFE SERVICE COORDINATION

STE. GENEVIEVE, MISSOURI

APPENDIX J

U.S. FISH AND WILDLIFE SERVICE COORDINATION

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

MARION ILLINOIS SUBOFFICE(ES)
Rural Route 3 - Box 198-A
Marion, Illinois 62959

IN REPLY REFER TO:

Commercial: 618-457-3659
FTS: 958-6659

PD

April 29, 1985

Colonel Gary D. Beech
District Engineer
St. Louis District
Corps of Engineers
210 Tucker Blvd., North
St. Louis, Missouri 63101

Dear Colonel Beech:

Enclosed is the Historic Ste. Genevieve, Missouri Flood Control Study; Final Fish and Wildlife Coordination Act Report. This report was prepared in satisfaction of coordination objectives, under authority of and in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended, 16 U.S.C. 661 et seq.) and the National Environmental Policy Act.

Information on project alternatives and individual features described in the attached report were taken from your draft feasibility report dated June 1984.

Sincerely yours,

Joseph A. Janecek

Joseph A. Janecek
Assistant Field Supervisor

Enclosure: 1
cc: US EPA (Koke)
MO DOC (Stucky)

HISTORIC STE. GENEVIEVE, MISSOURI FLOOD CONTROL STUDY; FINAL FISH AND WILDLIFE COORDINATION ACT REPORT

Submitted to St. Louis District,
U.S. Army Corps of Engineers

Prepared by: Alan L. Balliett, Fish and Wildlife Biologist
U.S. Department of Interior
Fish and Wildlife Service
Division of Ecological Services
Marion Illinois Suboffice
Joseph A. Janecek, Assistant Field Supervisor

April 1985

HISTORIC STE. GENEVIEVE, MISSOURI FLOOD CONTROL STUDY;
FINAL FISH AND WILDLIFE COORDINATION ACT REPORT

I. Introduction

This report is intended to satisfy planning requirements for the Historic Ste. Genevieve, Missouri Flood Control Study, conducted by the St. Louis District, U.S. Army Corps of Engineers. This study was authorized by a resolution sponsored by Congressman Parke M. Banta and adopted on June 17, 1948 by the committee on Public Works and Transportation of the U.S. House of Representatives. St. Louis District issued a feasibility report in June 1984. That report indicated there were no economically justified methods of protecting the City of Ste. Genevieve from flood damage, based on traditional Corps of Engineers' economic analysis. However, a structural alternative and further study was recommended by the Division Engineer based on a desire to protect the Nationally-Historic, French Colonial buildings and heritage of the city.

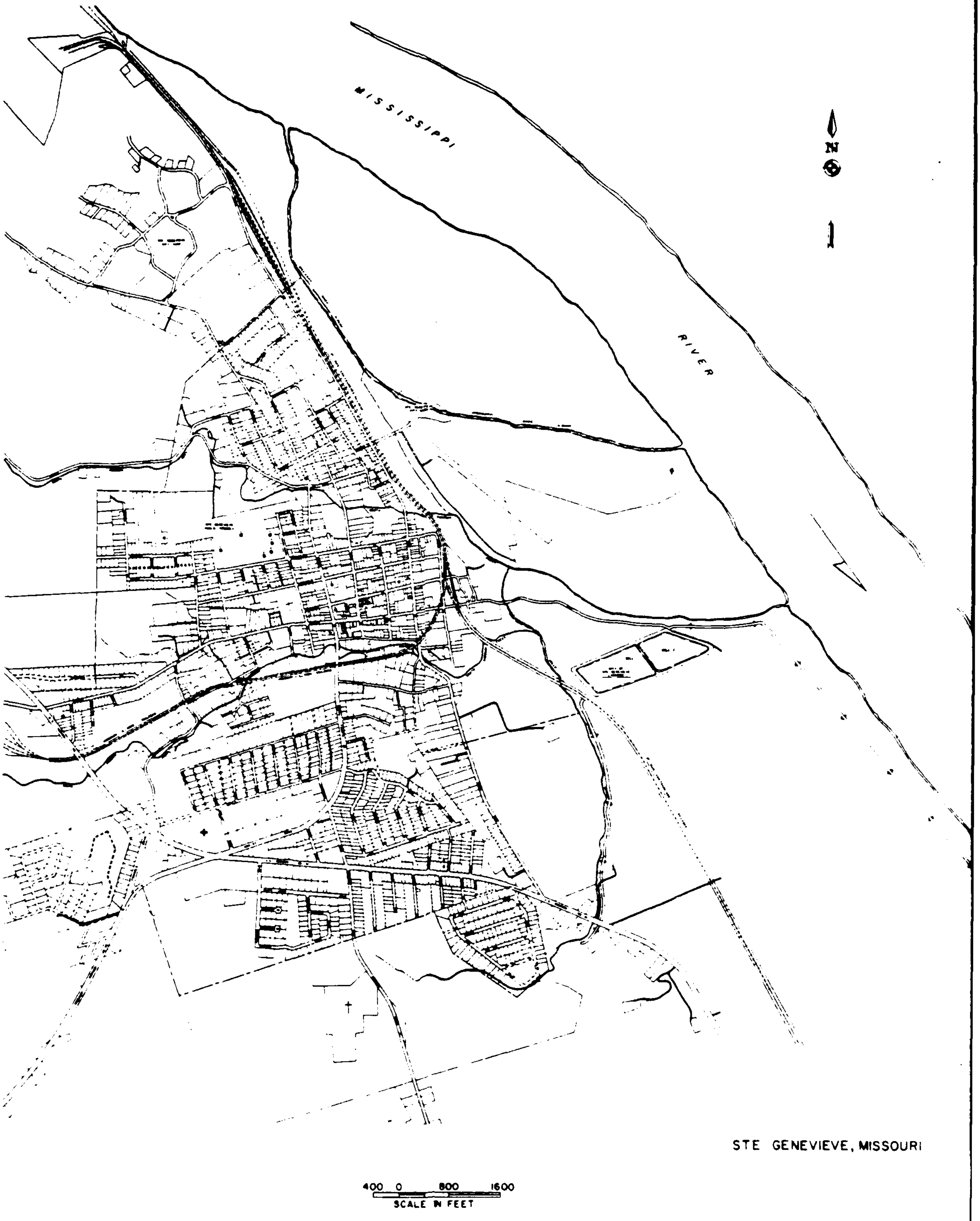
The Fish and Wildlife Service provided St. Louis District with Planning Aid Letters on November 19, 1981; April 20, 1982; July 14, 1982; and June 2, 1983. A Draft Fish and Wildlife Coordination Act Report (FWCAR) for the project was completed on September 22, 1983. St. Louis District provided comments on the draft report in a letter dated November 29, 1983 and again in their June 1984 feasibility report. This document incorporates those comments and supercedes the Draft FWCAR and previous Planning Aid Letters. The Fish and Wildlife Service also conducted a biological inventory on aquatic resources of the area and submitted a report on the same to St. Louis District during November 1982. Correspondence regarding Federally endangered species will be discussed in the endangered species section of this report.

This report was prepared under authority of and in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended, 16 U.S.C. 661 et seq.), Endangered Species Act of 1973, and the National Environmental Policy Act. Recommendations included in this report are consistent with the Fish and Wildlife Service's Mitigation Policy.

II. Base Condition

The study area is outlined in Figure 1. It contains the City of Ste. Genevieve and Mississippi River floodplain to the east of the city. The study area is urbanized and the non-urban area in the floodplain is intensely farmed for row crops. The city is divided by three streams: Valley Spring Branch, North Gabouri Creek and South Gabouri Creek. A remnant of a side-channel called Mississippi Slough is located in the floodplain. A small pond was recently created by scour from floodwater passing through an agricultural levee adjacent to Valley Spring Branch which broke during December 1982 flooding.

Figure 1



MISSISSIPPI
RIVER
N
STE GENEVIEVE, MISSOURI
400 0 800 1600
SCALE IN FEET

Fisheries

North and South Gabouri Creeks originate in the hills surrounding Ste. Genevieve and are characterized as having a cobble substrate and low base flows in their upstream section. Both streams are intermittent in their headwaters. The streams are for the most part undisturbed and forested in their upper section. The lower reaches have been channelized in the portions flowing through the Mississippi River floodplain and suffer from urban development within the City of Ste. Genevieve. South Gabouri Creek receives pollution from an adjacent limestone mining operation. These streams have been connected to Valley Spring Branch, which is also channelized in the Mississippi River floodplain, and discharge through a common channel to the Mississippi. Effluent from the City of Ste. Genevieve's sewage lagoons is discharged to the channelized confluence of the streams. Mississippi Slough is shallow and water levels are dependent on the level of the Mississippi River. The slough is nearly filled with sediment and the upper section has been partially filled by an abandoned landfill.

Fishery resources of the study area have been surveyed by the Fish and Wildlife Service in 1982. A copy of the survey report is included in Appendix A. Readers are referred to this report for a more detailed account of the fishes and their habitat in the study area. However, Mississippi Slough and the recently created pond were not surveyed and are, therefore, not included in the attached report.

The fishery of Mississippi Slough and the lower reaches of the Gabouri Creeks, Valley Spring Branch and their confluence is influenced to a large extent by the Mississippi River and contains fish normally found in large rivers. Though degraded by human encroachment, development, and pollution; these waters play an important role in providing slackwater and nursery habitat for Mississippi River fishes. Slackwater tributary habitats such as these have become more crucial to the survival of the fishery of the Mississippi River below Lock and Dam 26. This is due to the continued decline of such habitats in the river itself, resulting from the constriction of the river channel and the subsequent elimination of side channels.

The recently created pond was inspected by the author on June 23, 1983. Largemouth bass, gizzard shad, black bullhead, and sunfish were observed from the shore. A school of black bullhead fry and sunfish spawning beds were also observed, indicating that reproduction was already occurring. The fishery typifies that which once commonly occurred in oxbow lakes in the Mississippi River floodplain prior to the construction of the extensive drainage and levee system along the river. This construction resulted in draining of many of the oxbow lakes and prevented the continued movement of fish between the river and few remaining oxbow lakes behind the levees.

Wildlife

Undeveloped wildlife habitat in the project area is generally sparse and limited primarily to the narrow vegetated strips along the channelized streams in the Mississippi River floodplain. Most of these areas are

wooded and dominated by mature cottonwoods, willows, and silver maples. Urban areas and agricultural fields are the predominant habitat type. These types are generally regarded as having low wildlife value.

The project area, though highly developed, still provides habitat for a number of wildlife species. Wildlife which have become accustomed to urban surroundings such as squirrels, rabbits, pigeons, American robins, cardinals, English sparrows, and grackles are found in the City of Ste. Genevieve. Species which would frequent the vegetated strips along streams include; bobwhite quail, mourning doves, songbirds, hawks, owls, rabbits, opossums, and skunks. Mink, beaver, raccoons, and muskrats are semi-aquatic furbearers common to the area and would occur in and along streams. Crops residues in the agricultural fields provide a source of food for many bird and mammal species. Flooding of these agricultural fields attracts large numbers of waterfowl when it coincides with their spring and fall migrations.

Federally Endangered Species

St. Louis District prepared a biological assessment for the project which was transmitted to the Fish and Wildlife Service on June 22, 1983. On July 8, 1983, the Fish and Wildlife Service issued a biological opinion which stated that the project as proposed would not threaten the continued existence of Federally listed Threatened or Endangered Species provided the clearing of trees is scheduled between September 15 and April 1, as indicated in St. Louis District's biological assessment. The purpose for the scheduling is to avoid destroying any potential nursery colony of Indiana bats (Myotis sodalis) that may be present. Potential summer habitat for these species was reported to exist along the tree-lined streams and Mississippi Slough by St. Louis District. However, no Indiana bats have been reported from the area. The Fish and Wildlife Service recommended that, as an enhancement feature, clearing be limited to one bank of Mississippi Slough and the floodplain section of the streams. This would insure that the project area would have a continued supply of overmature and dead trees with exfoliating bark which provide sites for nursery colonies.

The bald eagle (Haliaeetus leucocephalus) winters along the Mississippi River in the vicinity of the project area. However, the Fish and Wildlife Service could find no evidence that eagles are attracted to the project area for feeding, roosting, or other purposes; and thus concluded that the project would not affect the species.

Recreation

Fish and wildlife-related recreation in the project area is limited due to the general lack of habitat. The major activity in the City of Ste. Genevieve is expected to be wildlife feeding and observation. There is evidence that some fishing occurs in the confluence of the streams near the Mississippi River. Commercial species are most prevalent and likely the most sought after species. The sections of stream in the City of Ste. Genevieve are very shallow and receive no fishing pressure. It appears that some hunting occurs in the agricultural fields, along the wooded borders and ditches in the

Mississippi River floodplain outside the city limits. Quail, doves, rabbits, and waterfowl are present and expected to provide limited hunting opportunity.

III. Fish and Wildlife Problems and Needs

The major problems affecting fish and wildlife in the project area which need to be corrected are a general lack of habitat and the degradation of remaining habitat resulting from human development. Most habitat in the Mississippi River floodplain section of the project area has been cleared for agricultural purposes, and habitat in the City of Ste. Genevieve is highly urbanized. Streams in the Mississippi River floodplain section of the project area have all been degraded by channelization. South Gabouri Creeks has been further degraded by limestone mining wastes. In addition, the streams' confluence receives treated municipal wastes. Mississippi Slough is badly silted and reportedly maintains very shallow water during low Mississippi River stages. The Slough has been further degraded by fill from a sanitary landfill.

IV. Future Without the Project

Fish and wildlife populations in the project area are expected to remain at current levels without the project. Most areas are developed to such an extent that very little unaltered habitat remains. A downward trend in urban wildlife populations could occur if intense urban development were to occur within the city and cause the loss of trees and shrubs which are necessary for their survival.

V. Fish and Wildlife Service Goals

The Fish and Wildlife Service's major goal for this project is to insure, in accordance with the provisions of the Fish and Wildlife Coordination Act, that ". . .wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs. . ." This goal can be met by inclusion of the mitigative measures discussed later on in this report as part of the Corps' preferred plan.

VI. Project Alternatives

No Corps Action - The Corps' no action plan involves no Federal project or action. Ste. Genevieve would continue to be flooded and the town will fight the Mississippi River floods with sand bag and other levees, relocation of movable items, and other efforts.

Plan 1 - This is the Corps of Engineers' recommended plan. It includes a major urban height levee that protects Ste. Genevieve from Mississippi River flooding, an interior drainage system that includes gravity drains and a 650 cfs pump station, channel widening with gabion slope protection on the tributary streams, bridge replacements and modifications on the tributary streams, small levees along the tributaries, and recreation facilities on land purchased for flood protection. This plan would provide 500-year protection from

Mississippi River flooding, and 25-year protection from flooding on North and South Gabouri Creeks. The plan also includes recreation measures associated with the Mississippi River levee and the measures on the tributary streams. Plan 1 is shown in Figure 2.

Plan 2 - This plan is similar to Plan 1 except that the urban height levee in Plan 2 is located on the south and east side of Valley Spring Branch. Since the Valley Spring Branch watershed drains into the area protected by the levee, an 800 cfs pump station is required to handle interior drainage. Larger gravity drain capacity is also specified. This measure was proposed by the officers of Ste. Genevieve County Levee District #2. The plan provides 500-year protection from Mississippi River flooding and 25-year protection from flooding on North and South Gabouri Creeks. It protects a few more structures than Plan 1, including a historic home. Plan 2 is shown in Figure 3.

Plan 3 - This plan is similar to Plans 1 and 2 except that the urban height levee in Plan 3 is east of the Ste. Genevieve sewage lagoon and well east of Valley Spring Branch. The levee is less visible from the south part of Ste. Genevieve than the Mississippi River levees in Plans 1 or 2. The levee also protects more structures than Plan 1, including a historic home, because it ties into high ground south of Valley Spring Branch. Plan 3 also includes degrading parts of the existing District #2 agricultural levee to increase the area available for ponding. This increased ponding capacity generally compensates for the additional drainage area in the Valley Spring Branch watershed, and the pump station required for Plan 3 is the same as for Plan 1, 650 cfs. Plan 3 provides the same level of protection as Plans 1 and 2. It is shown in Figure 4.

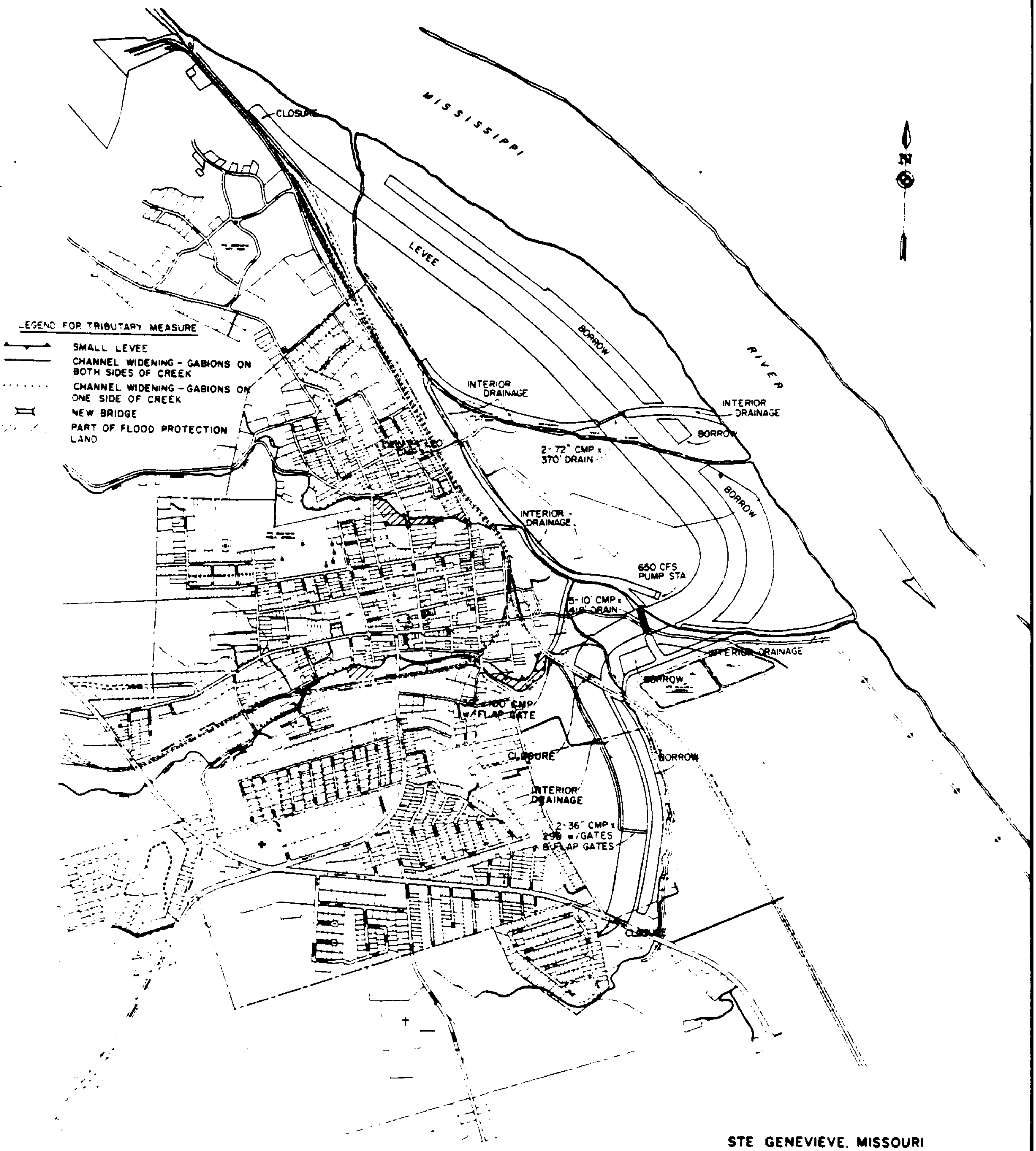
Plan 4 - This plan includes clearing and snagging on South and North Gabouri Creeks, a small levee along North Gabouri Creek, and floodproofing the Bilt Best Window Company warehouse. All the features of Plan 4 have not tangible economic benefits in excess of costs as measured in monetary terms. The recreation measure was not included in Plan 4 because it must be implemented in association with channel widening on the tributary streams and a levee along the Mississippi River. Plan 4 is shown in Figure 5.

VII. Environmental Impacts Associated With Each Alternative

No Corps Action - This alternative would have no adverse or beneficial impact on the natural environment.

Plan 1 - Major impacts associated with this alternative are degradation of 1.83 miles of stream habitat and loss of 6,255 feet of riparian habitat. Channel widening and modification in the Gabouri Creeks, Valley Spring Branch, and Mississippi Slough will have the greatest adverse environmental impact. Riparian habitat along the floodplain section of these waterbodies would be cleared to widen the streams. This habitat provides the only natural cover in the floodplain section of the project area for terrestrial species, and those species using it

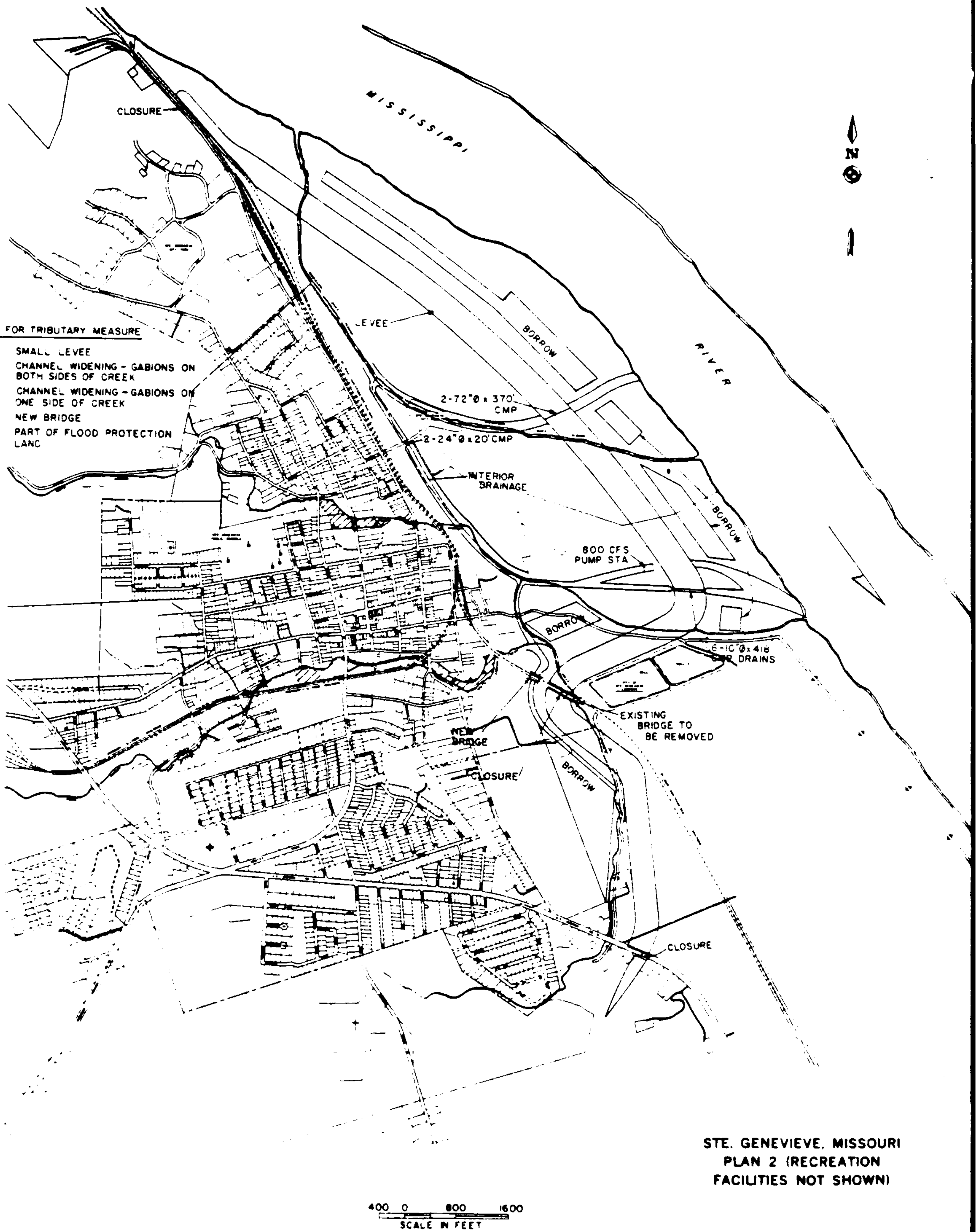
Figure 2



STE. GENEVIEVE, MISSOURI
PLAN 1 (RECREATION FACILITIES NOT SHOWN)

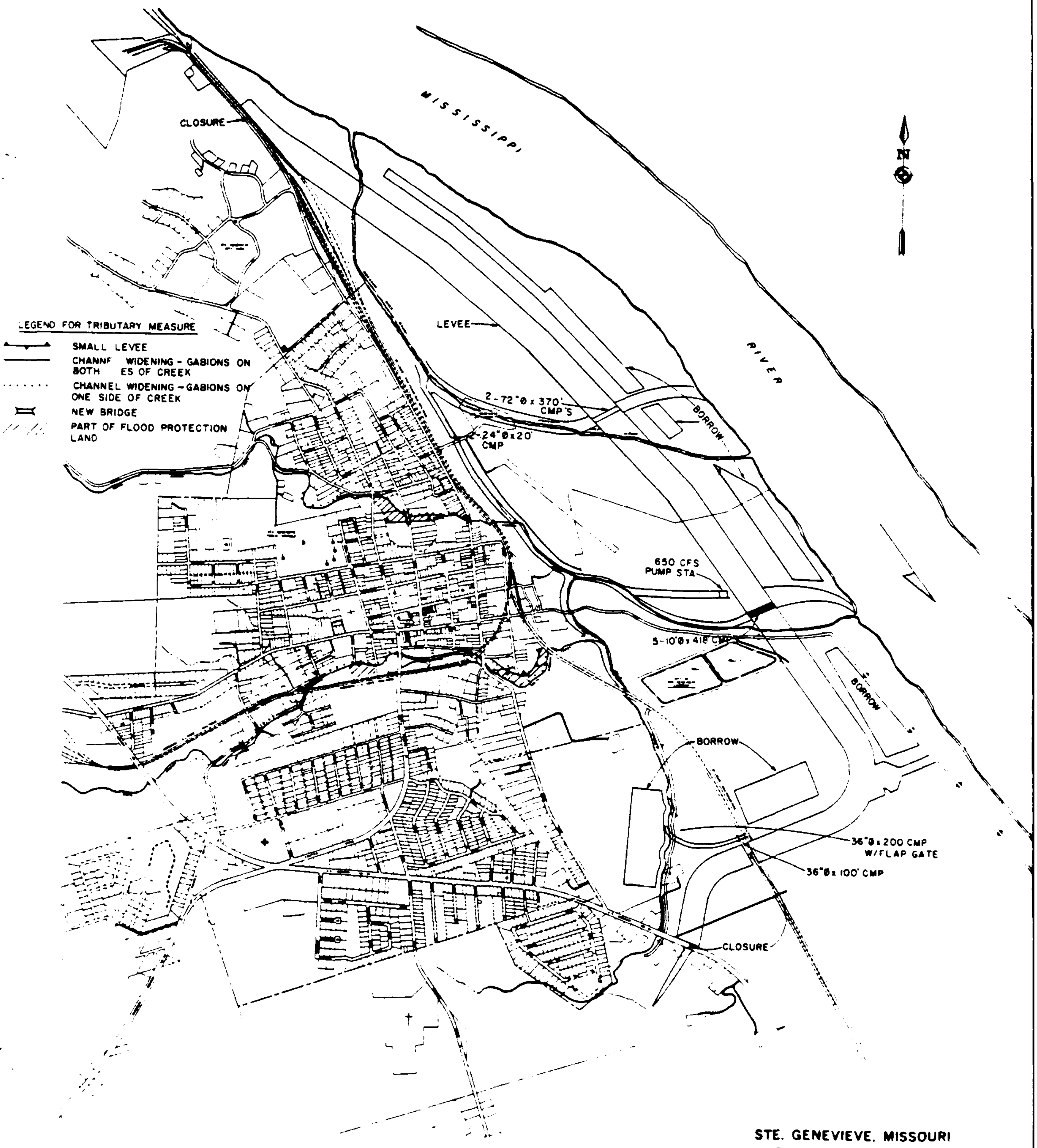
400 0 800 1600
SCALE IN FEET

Figure 3



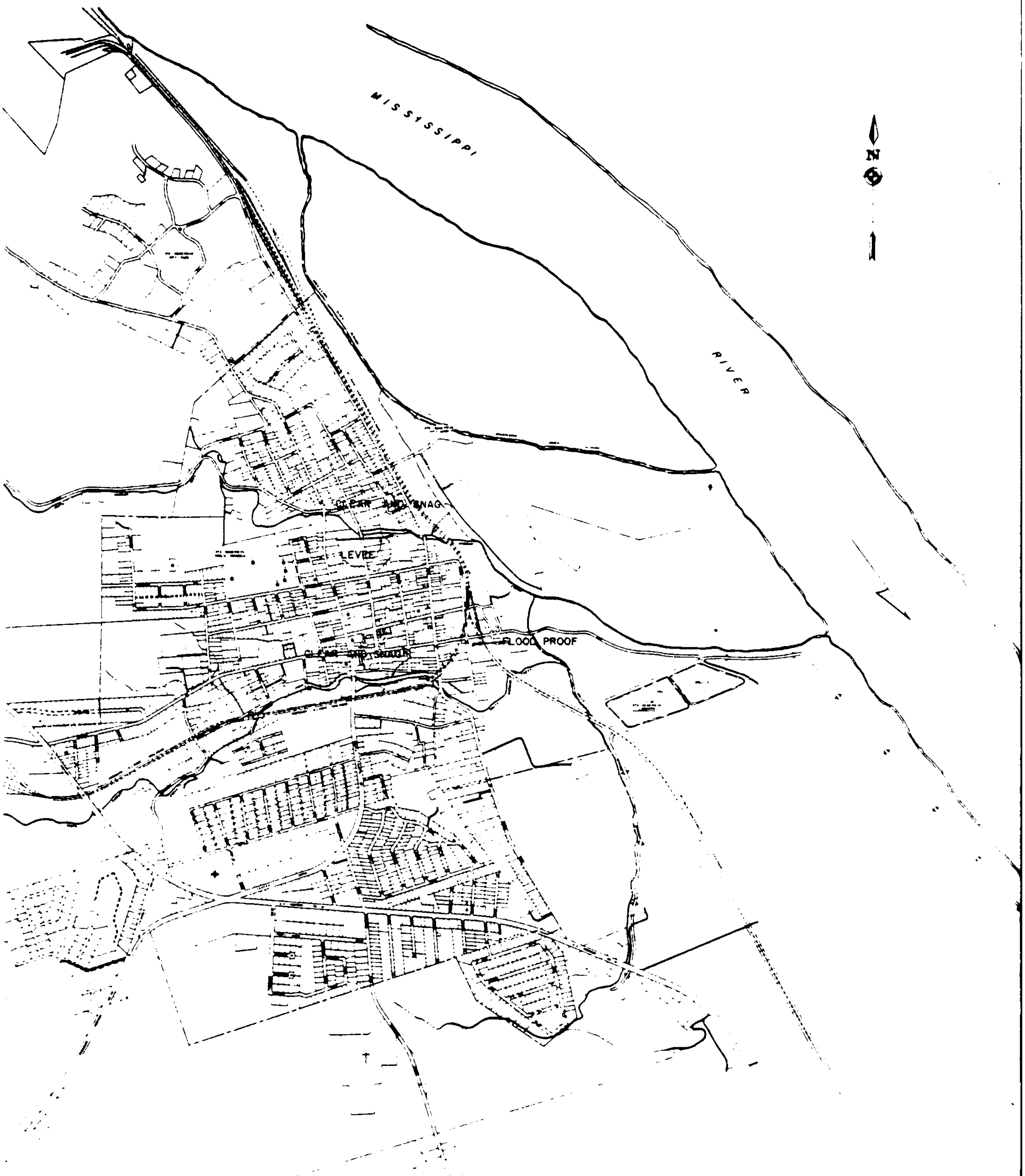
STE. GENEVIEVE, MISSOURI
PLAN 2 (RECREATION FACILITIES NOT SHOWN)

Figure 4



MISSISSIPPI
RIVER
N
CLOSURE
LEVEE
LEGEND FOR TRIBUTARY MEASURE
SMALL LEVEE
CHANNE WIDENING - GABIONS ON BOTH ES OF CREEK
CHANNEL WIDENING - GABIONS ON ONE SIDE OF CREEK
NEW BRIDGE
PART OF FLOOD PROTECTION LAND
2-72"Ø x 370' CMP'S
2-24"Ø x 20' CMP
BORROW
650 CFS PUMP STA
5-10'Ø x 418' CMP
BORROW
BORROW
36"Ø x 200 CMP W/FLAP GATE
36"Ø x 100' CMP
CLOSURE
STE. GENEVIEVE, MISSOURI
PLAN 3 (RECREATION FACILITIES NOT SHOWN)
400 0 800 1600
SCALE IN FEET

Figure 5



STE GENEVIEVE, MISSOURI
PLAN 4

for cover would be adversely affected by its loss. The woody border vegetation also provides shade for the adjacent streams. They would, therefore, be subject to higher and more drastic temperature fluctuations without the shading. Fish and other aquatic organisms intolerant of the higher temperatures would be lost from these environments.

Fish and aquatic life in the project area would suffer from temporary disruption by the construction activities. Sedimentation and turbidity, which are harmful to aquatic organisms would initially increase during construction and would remain at higher than normal levels until the scarified streambanks stabilize.

Stumps, logs, and debris provides cover for fish and aquatic life in the floodplain sections of the streams. Widening the streams would result in the degradation of this habitat and a general decrease in stream productivity.

The upper sections of North and South Gabouri Creeks are extremely shallow and subject to extreme low flows. Widening these stream sections would cause loss of existing stream channels and result in only a shallow rill of water flowing down the widened streambed. These aquatic habitats would thereafter support a less diverse benthic community and extremely limited fish population.

A positive benefit associated with this alternative is an increase of 79 acres of wetland habitat. A Fish and Wildlife Service recommended design of these wetlands is included in a later portion of this report.

Plan 2 - Impacts associated with this alternative are similar to those described in Plan 1. A similar 1.83 miles of stream would be degraded, but only 3,736 feet of riparian habitat would be lost. Wetland habitat would be increased by 93 acres.

Plan 3 - Impacts associated with this alternative are similar to those described for Plan 1. A total of 1.83 miles of stream would be degraded and 3,346 feet of riparian habitat would be lost. Wetland habitat will be increased by 108 acres.

Plan 4 - Only the upper sections of North and South Gabouri Creeks would be impacted by clearing and snagging. Shading will be lost and the streams would suffer from impacts associated with higher stream temperatures. This would adversely affect the more heat-sensitive organisms. The loss of instream cover would decrease stream productivity. Sedimentation and turbidity would increase during construction activities. A total of 0.83 miles of stream would be degraded along with 4,328 feet of riparian forest. No wetland habitat would be created.

VII. Plan Most Acceptable From a Fish and Wildlife Standpoint

The No Action Alternative is most acceptable from purely a fish and wildlife standpoint. This alternative would not cause the degradation and loss of habitats incurred with the various construction alternatives considered. Conditions for fish and wildlife would remain relatively constent.

IX. Measures that Should Be Included as an Integral Part of the Preferred Plan

The Fish and Wildlife Service recommended in the Draft FWCAR that the following measures be taken by St. Louis District to meet the provisions of the Fish and Wildlife Coordination Act:

1. A gated outlet should be constructed, as proposed, where levees cross tributary streams and the Mississippi Slough. This would insure continued movement of fish between the Mississippi River and internal drainages.

2. Stream widening should be limited to one bank of Mississippi Slough and the tributary streams in the floodplain. This would reduce the amount of riparian habitat loss and provide a continued source of shading for aquatic resources during certain diurnal periods.

3. An environmental buffer should be maintained along the cleared banks of the internal drainages. The areas once stabilized could be allowed to naturally revegetate with trees and shrubs.

4. Fish structures should be placed in the floodplain sections of the widened streams to replace instream cover lost through construction. Weighted brush or Christmas tree bundles and tire clusters are acceptable examples of the type of instream cover recommended.

5. A low-head water-control structure should be placed in the widened Mississippi Slough to prevent its drainage during low water stages on the Mississippi River. This would insure that the slough is maintained as an aquatic resource and may even improve existing coditions.

6. Trees and shrubs, which would provide additional food and cover for urban wildlife species, should be planted on project lands in areas where they would not interfere with other project objectives.

7. A low-flow channel should be created in the widened sections of North and South Gabouri Creeks within the City of Ste. Genevieve. This would insure that sufficient water depths are maintained to support fish and aquatic life.

8. Borrow areas should be developed into a bottomland-hardwood and slough-habitat complex, similar to that which once commonly existed along the Mississippi River. This would provide an opportunity to replace some of the formerly abundant, high value bottomland-hardwood habitat which has rapidly declined due to human development.

The above measures were recommended to provide a minimum level of protection to the fish and wildlife resources directly affected by project development. They would mitigate primary fish and wildlife losses and are, therefore, considered reasonable and proper. The measures could be applied entirely within project right-of-ways and would not substantially increase construction costs. They would satisfy the equal consideration provision of the Fish and Wildlife Coordination Act. We strongly recommended they be included in project design specifications transmitted for funding authorization.

The following summarizes St. Louis District's responses on the measures recommended in the Draft FWCA and the position of the Fish and Wildlife Service on those responses:

Measure #1 - This has been included in the current project plans.

Measure #2 - St. Louis District proposes to further investigate this measure and implement it if feasible. The Fish and Wildlife Service believes it is important to give this measure serious consideration since it would reduce riparian habitat loss by approximately half.

Measure #3 - This has been included in current project plans.

Measure #4 - This has been included in current project plans.

Measure #5 - St. Louis District has indicated that they will further investigate this measure. They suggest that in lieu of placing a low-head water-control structure in Mississippi Slough, as recommended in the Draft FWCAR, the gravity drain invert be placed slightly higher than the Mississippi Slough invert. The Fish and Wildlife Service has no objection to this suggested plan provided sufficient water levels are maintained in Mississippi Slough to support indigenous fish and aquatic life.

Measure #6 - St. Louis District proposes to allow natural vegetation to grow on project lands that do not need to be maintained instead of planting trees and shrubs as recommended in the Draft FWCAR. Their proposal would meet the intended objective of providing food and cover for wildlife species as long as human disturbance of the vegetation is prohibited.

Measure #7 - St. Louis District believes the low-flow channel recommended in this measure would be eroded or filled in shortly after construction. They believe the proposed ditches will form their own low flow channels. They will investigate placement of some low-flow dams made from gabions in the streams to

provide permanent water during low flows. The Fish and Wildlife Service finds this to be a suitable alternative for accomplishing the objective of this measure.

Measure #8 - St. Louis District has commented that natural succession in the borrow pits will create a valuable bottomland-hardwood slough complex. The Fish and Wildlife Service believes that this is a valid assumption provided the borrow pits have proper configuration and bottom contour. It is recommended that St. Louis District consult with Missouri Department of Conservation and Fish and Wildlife Service in designing the borrow pits and the structures proposed in Measures #4, #5, and #7 for assistance in fish and wildlife related matters.

X. Conclusion

A much broader approach is needed to solve flooding problems on the river rather than site-specific solutions such as this one. To date, the flooding problem has been only transposed from one area to another. Flood levels on the river continue to rise, although discharges have not correspondingly increased. A 6-inch increase in flood heights resulting from this project during a 100-year-frequency flood may not be considered significant. However, when the cumulative effects of the numerous other levee systems already consturcted or proposed and the corrective actions taken elsewhere to compensate for flood condition changes brought about by this project are taken into consideration, the significance becomes readily apparent. St. Louis District is encouraged to develop more wide-ranging solutions to flooding than the methods currently used. The Fish and Wildlife Service offers its assistance in this endeavor.

FISH AND BENTHOS SURVEY OF VALLEY SPRING BRANCH, NORTH GABOURI CREEK AND SOUTH GABOURI CREEKS, STE. GENEVIEVE COUNTY, MISSOURI

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ABSTRACT

Two sites were sampled on both North and South Gabouri Creeks and another at their confluence for fish and benthos during late August and early September of 1982. Similar sampling was conducted on Valley Spring Branch. Twenty-four fish species and 16 benthic taxa were collected from North Gabouri Creek, 13 fish species and 32 benthic taxa from South Gabouri Creek, 11 fish species and no benthic taxa from the confluence of the Gabouri Creeks, and 4 fish species and 1 benthic taxon from Valley Spring Branch.

INTRODUCTION

The U.S. Fish and Wildlife Service conducted fish and benthos surveys on Valley Spring Branch, North and South Gabouri Creeks in Ste. Genevieve County, Missouri at the request of the St. Louis District, U.S. Army Corps of Engineers. The purpose of this survey was to evaluate the aquatic biological resources in the proposed Ste. Genevieve flood control project area.

SITE SELECTION AND DESCRIPTION

The locations of the streams sampled and sample sites are identified on Attachment #1. It should be noted that the Weingarten Quadrangle used for this purpose is quite dated (1907). The side channel (Site 6) has been altered and is no longer as depicted on the map.

North Gabouri Creek is a narrow stream with low base flows. The upper end is probably intermittant during drought periods. The stream passes through a mixture of pasture, forest, and cropland in its upper reach and the Village of Ste. Genevieve in its lower reach. The stream is normally clear except during runoff events.

Missouri Department of Natural Resources (1981) investigated a fish kill on North Gabouri Creek on April 22, 1981, which resulted from the release of hog manure from a confined hog raising operation. All fish and aquatic organisms were reported killed within a 2 mile reach of the stream. The location of the spill is illustrated on Attachment 1.

The upper sampling site (#1) on this stream is shallow. It has a cobble and gravel substrate with little instream cover. Streambank vegetation is composed of cottonwoods, locusts, sweetgum, grasses, and forbs. Riffles are 4 times as common as pools, the latter ranging between 50 and 60 feet in length and holding the majority of fish taken. Shading was adequate.

The lower sampling site (#2) is also shallow and has a mixture of bedrock, gravel, cobble, and muck for substrate. Instream cover consists of a mixture of man-made and natural debris. Streambank vegetation consisted of cottonwoods, silver maple, and forbs. The stream is adequately shaded. There is a fairly even mixture of pools and riffles. Pools range between 50 and 150 feet in length. They provide excellent cover for fish.

South Gabouri Creek is similar in width, base flows and riparian habitat to North Gabouri Creek. The stream was noted to be dry in its far upper reach during the survey. It is normally clear during low flows in its upper reach, becoming turbid during periods of runoff. The stream has milky color in its lower reaches, presumably from limestone mining wastes.

The upper sampling site (#3) on this stream is shallow. It has a cobble and gravel substrate with sparse instream cover. Vegetation on the streambank consists mostly of sweetgum, cottonwoods, grasses and forbs which provides ample shade. Pools range between 20 and 40 feet in length; however, riffles are apparently 3 times more abundant. The pools provide excellent habitat, especially for centrarchids.

This stream's lower station (#4) is very shallow. It has a substrate comprised of gravel and limestone mining wastes. In areas of heavy waste deposits, the material is over one-foot thick and is marl-like in consistency. Streambank vegetation is mainly grasses and forbs which provide little shading. Instream cover is limited to debris piles around bridges. Pools are approximately 20 feet in length, and comprise approximately 20 percent of the instream habitat. The majority of this site appears to have been channelized in the past to facilitate road construction.

The confluence of the Gabouri Creeks (Site #6) is wide and quite deep. Water levels in this segment of stream are influenced by those of the Mississippi River. The water is normally turbid. Sewage effluent from nearby lagoons enters the stream at the site. The bottom substrate consists of muck. Streambank vegetation, composed of silver maple, willows, grasses and forbs, provides ample shading. The low bank is devoid of groundcover vegetation. The site has no riffles. Debris at normal water levels and flooded timber at high water levels provide instream cover.

Only the lower section of Valley Spring Branch (#5) was sampled. This section of stream has been channelized and leveed in the past and thus is uniform in width. Water levels are very shallow during low flows. The water was very turbid during sampling. The bottom substrate consists of deep muck. Instream cover is scarce. Grasses and forbs, though dense, provide very little shading.

MATERIALS AND METHODS

Fish and benthos were sampled at each site. All sites, except #6, were electrofished with a Smith-Root, pulsed D.C., type VII backpack shocker. Site #6 was sampled with a pulsed D.C. boat electrofishing unit. Seining was conducted where practical, in an attempt to collect species which would otherwise be missed by electrofishing. A 12 X 12-inch surber sampler was used to collect benthos in the coarse substrates of sites 1, 2, 3 and 4 and a 6 X 6-inch ponar grab sampler was used in the soft substrates of 5 and 6. Five benthic samples representative of the substrates and habitats were collected at each site.

RESULTS AND DISCUSSION

The one-time sampling conducted for this investigation may not accurately portray the aquatic biological community in the study area. Low water levels at all sites, except #6, concentrated fish and resulted in higher density than would be observed at higher water levels. Species composition of the fish populatation would likely vary if the sampling would have coincided with spawning of Mississippi River fishes. Benthic communities also vary significantly in species composition on a seasonal basis.

Fisheries - Twenty-five species of fish were collected or observed in North Gabouri Creek (See Table 1). Central stoneroller (*Campostoma anomalum*), green sunfish (*Lepomis cyanellus*), and rainbow darter (*Etheostoma caeruleum*) were the most abundant species at the upper sampling site and black bullhead (*Ictaluras melas*), emerald shiner (*Notropis atherinoides*), and bluegill (*Lepomis machrochirus*) at the lower site. A fishable population of sport fish, mainly centrarchids, exists in the stream but most specimens collected were not of harvestable size. Rainbow darters, which are not tolerant of turbidity, were found in the upper part of the stream. Most other species taken are moderately tolerant of adverse environmental conditions. The presence of juvenile carp (*Cyprinus carpio*), smallmouth buffalo (*Ictiobus bubalus*), and freshwater drum (*Aplodinotus grunniens*) indicates the area serves as a nursery area for the Mississippi River.

Thirteen species of fish were taken from South Gabouri Creek. Green sunfish and central stoneroller were most abundant at the upper sampling site and, green sunfish and golden redhorse (*Moxostoma erythrurum*) at the lower sampling site. Mississippi River fishes such as shortnose gar (*Lepisosteus platostomus*), carp, smallmouth and bigmouth buffalo (*Ictiobus cyprinellus*) were found in the lower section of stream. A fishable population of green sunfish and largemouth bass (*Micropterus salmoides*) exists in the upper end of this stream but harvestable-size fish were rare.

Black bullhead, gizzard shad (*Dorosoma cepedianum*), largemouth bass, and green sunfish (in that order of abundance) were taken from Valley Spring Branch. Past channelization and extremely low water levels limited suitable fish habitat. Sampling efficiency at this site was reduced by the difficulty experienced in working the soft bottom. Because of this, the list of species collected is considered incomplete.

The calm water habitat at the confluence of the Gabouri Creeks attracts fish from the Mississippi River. Eleven species were taken at this site. Of these, bigmouth buffalo, gizzard shad, carp, and river carpsucker (*Carpiodes carpio*) were most abundant. The site appears capable of supporting a commercial fish population. A channel catfish (*Ictalurus punctatus*), 3 white bass (*Morone chrysops*), and a paddlefish (*Polydon spathula*), all of which are important sport and/or commercial species, were taken. Deep water levels limited sampling efficiency at this site.

Benthos - Sixteen benthic taxa were taken from North Gabouri Creek (See Table 2). *Gammarus pseudolimnaeus* was the most abundant taxon taken at the upper sampling site and chironomids, oligochaetes, and mayflies (*Caenis* sp.) at the lower site. Thirty-two benthic taxa were collected at South Gabouri Creek. Mayflies (*Stenonema* sp. and *Caenis* sp.) and *Gammarus pseudolimnaeus*

were predominant at the upper site and mayflies (Caenis sp.), chironomids, cranefly larva (Tipulidae), and snails (Physa sp.) at the lower site. The sample taken at Valley Spring Branch was comprised entirely of oligochaetes which were densely populated. No organisms were taken at the confluence of the Gabouris. However, sampling efficiency at this site was poor. Chironomids and oligochaetes normally inhabit soft substrates of the type found at the site.

According to Hilsenhoff (1977) and Weber (Op. Cit.) benthic organisms taken in this survey generally have a wide range of tolerance to organic pollution. More detailed identification of invertebrates, may reveal the presence of distinctly tolerant or intolerant organisms.

Species Diversity - The following discussion is based on diversity and evenness values found on Tables 1 and 2. Because of limited sampling effort and inherent weaknesses in the statistical formulas used, evenness values given should be interpreted with caution.

Based on the Shannon-Weaver Diversity and MacArthur's Evenness Indices (Weber 1973), South Gabouri Creek would appear to maintain a more diverse and evenly distributed population of macroinvertebrates than North Gabouri Creek. The indices further suggest that the macroinvertebrate populations in North Gabouri Creek are more stressed than those the of South Gabouri branch. Low diversity and evenness values reported for North Gabouri Creek may have resulted from the previously described hog manure spill. Macroinvertebrates in the Valley Spring Branch appear to be highly stressed. No assumptions are made regarding the confluence of the Gabouris, since no macroinvertebrates were collected at the site.

Fish populations in North Gabouri are generally more diverse than those of the South Gabouri. Diversity and evenness indices from the lower sampling stations on both streams are higher than the upper stations, due to the presence of Mississippi River fishes. Valley spring Branch data displayed a diversity index indicating a stressed environment. However, these low values are due, at least in part, to poor sampling efficiency.

CONCLUSION

Thirty-one species of fish and 34 benthic taxa were identified in the project area. North and South Gabouri Creeks support a limited sport fishery with a diverse forage fish base. Their lower portions serve as nursery habitat for Mississippi River fishes. The confluence of these streams serve as slack water habitat for a number of Mississippi River fish, some of which have commercial and sport value. The aquatic habitat value of the lower section of Valley Spring Branch appears to be limited by past channelization and periodic low water levels.

Limestone mining wastes appear to have some affect on the lower section of South Gabouri Creek. Fish population in the lower section of stream were more diverse than those of the upper section. But this greater diversity is attributable to the presence of adult and juvenile fish indigenous to the Mississippi River. Fish populations in the lower section are substantially less dense than the upper section. Benthic populations in the lower section of stream are less diverse than those of the upper section.

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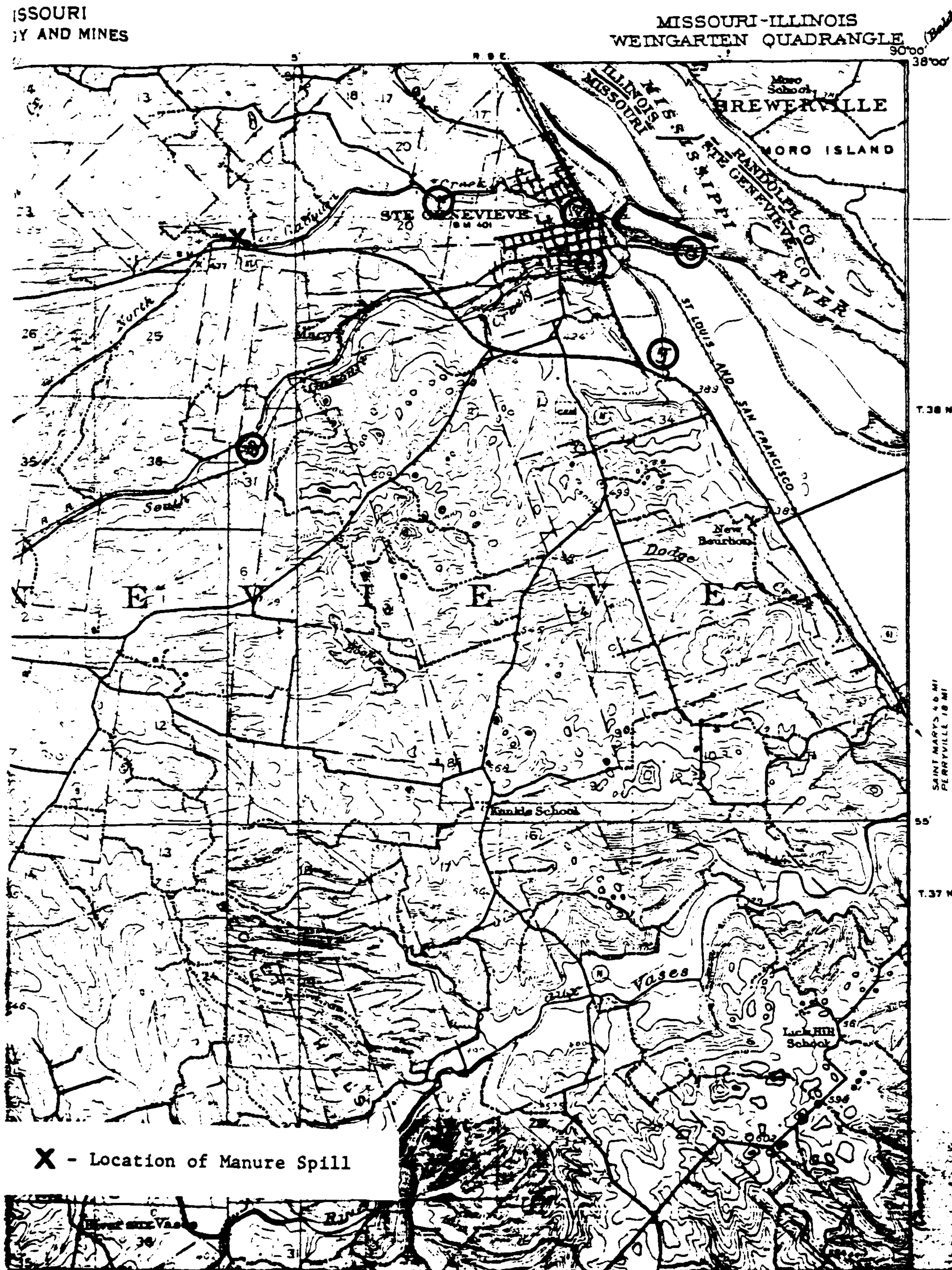
ATTACHMENT #1



X - Location of Manure Spill

TABLE 1: FISH COLLECTED IN THE STE. GENEVIEVE PROJECT AREA

SPECIES	SITE #1 No.	SITE #1 %	SITE #2 No.	SITE #2 %	SITE #3 No.	SITE #3 %	SITE #4 No.	SITE #4 %	SITE #5 No.	SITE #5 %	SITE #6 No.	SITE #6 %
Chestnut lamprey (Ichthyomyzon castaneus)	-	-	-	-	-	-	-	-	-	-	1	2.0
Paddlefish (Polyodon spathula)	-	-	-	-	-	-	-	-	-	-	1	2.0
Shortnose gar (Lepisosteus platostomus)	-	-	-	-	-	-	1[B]	3.2	-	-	6	12.0
Gizzard shad (Dorosoma cepedianum)	-	-	8	3.7	-	-	1	3.2	9	25.0	11	22.0
Central stoneroller (Campostoma anomalum)	171	38.9	-	-	70	33.2	-	-	-	-	-	-
Carp (Cyprinus carpio)	-	-	3	1.4	-	-	3	9.7	-	-	4	8.0
Emerald shiner (Notropis atherinoides)	-	-	44	20.3	-	-	1	3.2	-	-	-	-
Red shiner (Notropis lutrensis)	-	-	2	0.9	-	-	-	-	-	-	-	-
Mimic shiner (Notropis volucellus)	-	-	18	8.3	-	-	-	-	-	-	-	-
Bluntnose minnow (Pimephales notatus)	12	2.7	1	0.5	-	-	-	-	-	-	-	-
Fathead minnow (Pimephales promelas)	-	-	2	0.9	-	-	-	-	-	-	-	-
Creek chub (Semotilus atromaculatus)	33	7.5	-	-	17	8.1	-	-	-	-	-	-
River carpsucker (Carpiodes carpio)	-	-	-	-	-	-	-	-	-	-	6	12.0
White sucker (Catostomus commersoni)	34	7.7	-	-	-	-	-	-	-	-	-	-
Smallmouth buffalo (Ictiobus bubalus)	-	-	2	0.9	-	-	2	6.5	-	-	1	2.0
Bigmouth buffalo (Ictiobus cyprinellus)	-	-	-	-	-	-	1	3.2	-	-	13	26.0
Golden redhorse (Moxostoma erythrurum)	-	-	1	0.5	-	-	9	29.0	-	-	-	-
Black bullhead (Ictaluras melas)	-	-	55	25.3	-	-	-	-	22	61.1	-	-
Yellow bullhead (Ictaluras natalis)	2	0.5	5	2.3	11	5.2	-	-	-	-	-	-
Channel catfish (Ictaluras punctatus)	-	-	1	0.5	-	-	-	-	-	-	1	2.0
Northern studfish (Fundulas catenatus)	-	-	A*	-	-	-	-	-	-	-	-	-
Mosquitofish (Gambusia affinis)	-	-	9	4.1	-	-	-	-	-	-	-	-
White bass (Morone chrysops)	-	-	-	-	-	-	-	-	-	-	3	6.0
Green sunfish (Lepomis cyanellus)	129	29.3	16	7.4	106	50.2	10	32.3	1	2.8	-	-
Warmouth (Lepomis gulosus)	-	-	1	0.5	-	-	-	-	-	-	-	-
Bluegill (Lepomis machrochirus)	3	0.7	36	16.6	3	1.4	3	9.7	-	-	-	-
Longear sunfish (Lepomis megalotis)	-	-	1	0.5	-	-	-	-	-	-	-	-
Largemouth bass (Micropterus salmoides)	-	-	5	2.3	4	1.9	-	-	4	11.1	-	-
Black crappie (Pomoxis nigromaculatus)	-	-	5	2.3	-	-	-	-	-	-	-	-
Rainbow darter (Etheostoma caeruleum)	56	12.7	-	-	-	-	-	-	-	-	-	-
Freshwater drum (Aplodinotus grunniens)	-	-	2	0.9	-	-	-	-	-	-	3	6.0
TOTAL	440	100.0	217	100.1	211	100.0	31	100.0	36	100.0	50	100.0

	SITE #1	SITE #2	SITE #3	SITE #4	SITE #5	SITE #6
TOTAL SPECIES	8	20	6	9	4	11
STATION LENGTH (Feet)	600	700	800	600	300	1900
STATION AREA (Acres)	0.10	0.19	0.11	0.14	0.07	1.96
ELECTROFISHING CATCH PER UNIT EFFORT (Fish/hour)	1600	885	959	214	720	41
DIVERSITY	2.22	3.64	1.74	2.59	1.43	2.95
EVENNESS	.78	0.91	0.72	0.92	0.84	0.99

A - Observed at site but not captured.

B - Trapped in pool after survey was conducted.

TABLE 2: BENTHOS COLLECTED IN THE STE. GENEVIEVE PROJECT AREA

SPECIES	SITE #1 #/m²	SITE #1 %	SITE #2 #/m²	SITE #2 %	SITE #3 #/m²	SITE #3 %	SITE #4 #/m²	SITE #4 %	SITE #5 #/m²	SITE #5 %	SITE #6 #/m²	SITE #6 %
COELENTERATA												
HYDROIDEA												
HYDRIDAE												
Hydra	-	-	-	-	2	0.8	-	-	-	-	-	-
PLATYHELMINTHES												
TURBELLARIA	20	1.6	-		-	-	-	-	-	-	-	-
NEMATOMORPHA												
Gordius	-	-	-	-	2	0.8	-	-	-	-	-	-
ANNELIDA												
OLIGOCHAETA												-
HAPLOTAXIDA												
NAIDIDAE	-	-	9	18.4	9	3.4	-	-	62,500*	100.0	-	-
ARTHROPODA												
CRUSTACEA												
AMPHIPODA												
GAMMARIDAE												
Gammarus pseudolimnaeus	1,039	84.5	-	-	41	15.5	-	-	-	-	-	-
ISOPODA												
ASELLIDAE												
Asellus brevicauda	9	0.7	-	-	22	8.3	-	-	-	-	-	-
COLLEMBOLA												
ISOTOMIDAE												
Isotoma	-	-	2	4.1	-	-	-	-	-	-	-	-
INSECTA												
EPHEMEROPTERA												
HEPTAGENIIDAE												
Stenonema	63	5.1	4	8.2	76	28.7	7	2.3	-	-	-	-

TABLE 2: BENTHOS COLLECTED IN THE STE. GENEVIEVE PROJECT AREA (Continued)

SPECIES	SITE #1		SITE #2		SITE #3		SITE #4		SITE #5		SITE #6	
	#/m^2	%	#/m^2	%	#/m^2	%	#/m^2	%	#/m^2	%	#/m^2	%
CAENIDAE												
Caenis	33	2.7	9	18.4	63	23.8	83	26.7	-	-	-	-
SIPHLONURIDA												
Siphlonurus	-	-	-	-	-	-	20	6.4	-	-	-	-
ODONATA												
COENAGRIONIDAE												
Argia	-	-	-	-	2	0.8	-	-	-	-	-	-
HEMIPTERA												
MESOVELIIDAE	-	-	-	-	2	0.8	-	-	-	-	-	-
VELIIDAE	-	-	-	-	2	0.8	-	-	-	-	-	-
CORIXIDAE	-	-	2	4.1	2	0.8	-	-	-	-	-	-
UNIDENTIFIED	-	-	-	-	-	-	4	1.3	-	-	-	-
TRICHOPTERA												
HYDROPSYCHIDAE												
Cheumatopsyche	26	2.1	2	4.1	4	1.5	-	-	-	-	-	-
Parapsyche	-	-	-	-	2	0.8	-	-	-	-	-	-
PSYCHOMYIIDAE	11	0.9	-	-	2	0.8	-	-	-	-	-	-
HYDROPTILIDAE	-	-	2	4.1	2	0.8	2	0.6	-	-	-	-
MOLANNIDAE												
Molanna	-	-	4	8.2	-	-	2	0.6	-	-	-	-
COLEOPTERA												
ELMIDAE												
Stenelmis	22	1.8	-	-	2	0.8	-	-	-	-	-	-
HYDROPHILIDAE												
Tropisturnus	-	-	-	-	2	0.8	7	2.3	-	-	-	-
Berosus	-	-	-	-	-	-	17	5.5	-	-	-	-

TABLE 2: BENTHOS COLLECTED IN THE STE. GENEVIEVE PROJECT AREA (Continued)

SPECIES	SITE #1		SITE #2		SITE #3		SITE #4		SITE #5		SITE #6	
	#/m²	%	#/m²	%	#/m²	%	#/m²	%	#/m²	%	#/m²	%
DIPTERA												
TIPULIDAE	4	0.3	-	-	9	3.4	35	11.3	-	-	-	-
PSYCHODIDAE	-	-	-	-	-	-	2	0.6	-	-	-	-
CULICIDAE	-	-	-	-	-	-	7	2.3	-	-	-	-
CHAOBORIDAE	-	-	-	-	-	-	4	1.3	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	2	0.6	-	-	-	-
CHIRONOMIDAE	2	0.2	11	22.4	4	1.5	80	25.7	-	-	-	-
STRATIOMYIDAE	-	-	-	-	-	-	2	0.6	-	-	-	-
TABANIDAE	-	-	-	-	2	0.8	-	-	-	-	-	-
UNIDENTIFIED PUPA	-	-	-	-	-	-	2	0.6	-	-	-	-
MOLLUSCA												
GASTROPODA												
BASOMMATOPHORA												
PHYSIDAE												
Physa	-	-	4	8.2	11	4.2	35	11.3	-	-	-	-
PLANORBIDAE	-	-	-	-	2	0.8	-	-	-	-	-	-
TOTAL DENSITY	1,229	99.9	49	100.2	265	100.7	311	100.0	62,500*	100.0	0	0
TOTAL # TAXA	10		10		22		17		1		0	
DIVERSITY	1.04		3.06**		3.15		3.03		0.00		-	
EVENNESS	0.20		1.20**		0.59		0.71		1.00		-	

*Estimate
**Invalid due to small sample size.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

CARBONDALE FIELD OFFICE (ES)
Federal Building, Room 115C
250 West Cherry Street
Carbondale, Illinois 62901

IN REPLY REFER TO:

Commercial: 618-457-3659
FTS: 958-6659

November 19, 1981

Colonel Robert J. Dacey
District Engineer
St. Louis District
Corps of Engineers
210 Tucker Blvd., North
St. Louis, MO 63101

Dear Colonel Dacey:

Thank you for including Alan Balliett of our staff at the scoping meeting for the Historic Ste. Genevieve Flood Control Project. The meeting was very informative and has brought several issues of possible concern to our attention.

We are informed that local interests support construction of a levee able to withstand a 500-year-frequency flood (Urban Development Flood). To accomplish this degree of protection, the easternmost section of the levee would abut against and parallel the Mississippi River shoreline. Construction of a levee of such a proportions adjacent to the river would cause a major constriction in the floodplain leading to additional flooding upstream. We suggest that if the Urban Development Flood levee is considered as a project alternative, the potential increase in flood crests be assessed as part of the project review process.

Widening North and South Gabouri Creeks was discussed as a possible means to alleviate flash flooding. If floodways are enlarged, modifications to the low water channels of these streams should be avoided, especially outside the Mississippi River floodplain. The section of the streams outside the floodplain have a cobble bottom and low volume of flow during normal flow periods. As a result, the low water channels are very narrow and quite shallow. Widening the stream beds would disperse low water flows across a greater surface area and reduce stream depths. This would adversely affect fish and aquatic life currently existing in the streams.

We look forward to continued coordination on this project. Please advise us if we can be of any further assistance.

Sincerely,

Joseph A. Janecek

Joseph A. Janecek
Field Supervisor

cc: MODOC
ILDOC
USEPA

United States Department of the Interior

FISH AND WILDLIFE SERVICE

CARBONDALE FIELD OFFICE (ES)
Federal Building, Room 115C
250 West Cherry Street
Carbondale, Illinois 62901

IN REPLY REFER TO:

Commercial: 618-457-3659
FTS: 958-6659

April 20, 1982

Jim Zerega
St. Louis Distict
Corps of Engineers
210 Tucker Blvd., North
St. Louis, MO 63101

Dear Mr. Zerega:

This letter is in reference to the March 3 and 17 site inspections, of the Ste. Genevieve Study Area attended by Alan Balliett, of our staff.

Construction of the levees as proposed in Plan 3 (Central Area Flood Protection) would occur predominantly in highly-developed areas. However, the north to south aligned levee located east of the abandoned lime kiln would result in the loss of a small area of partially-wooded wildlife habitat and some agricultural land. A number of individual trees may need to be removed in town to facilitate levee construction. The project as proposed in Plan 3 would have minor overall affect on terrestrial wildlife. Taking agricultural land out of production, however, could be controversial if it is classified as prime farmland.

Construction of floodwalls and levees adjacent to North and South Gabouri Creeks will cause some constriction of the streams' floodplains when they overtop their banks. As a result, an increase in streambed scouring may occur. Benthic organisms and fish may be adversely affected by the increased scouring.

Planting wildlife-preferred trees and shrubs on project lands adjacent to the levees and floodwalls should be considered as an EQ feature. The trees and shrubs would provide food, cover, and nesting sites for urban wildlife. Such plantings could also make the project more aesthetically pleasing by concealing levees and floodwalls.

We believe that the use of dry dams and permanent reservoirs as flood detentions measures in the headwaters of North and South Gabouri Creeks should be actively investigated. These structures offer advantages and disadvantages from an environmental viewpoint which should be considered prior to selecting other structural alternatives.

The major advantage with permanent reservoir flood retention is that it offers an opportunity to develop a sport fishery and other water-related forms of recreation where none currently exist. Development of a sport fishery and other water-related recreational opportunities could be considered as EQ features of the this alternative.

Disadvantages with the permanent reservoirs include loss of existing land uses (cropland and pasture) in the pooled area of the reservoir. Some woodland would also be flooded or cleared for construction of the dikes. The flooded timber would, however, provide excellent habitat for fish.

Low base flows of North and South Gabouri Creeks may cause several problems in the maintenance of reservoirs. Filling could take a long time and may be dependent on heavy runoff. Maintaining desired pool level elevations and adequate base flows to sustain fish and aquatic life downstream from the reservoir may be difficult, if not impossible. The streams' hydrology would have to be examined in greater detail to determine if the two aforementioned goals could be met. Flushing time (length of time to replace the existing volume of water in the reservoir) is expected to be lengthly, possibly resulting in a build-up of nutrients in the reservoir which could potentially have adverse impacts on water quality.

We are unable to address impacts of reservoirs on fish and aquatic life currently existing in North and South Gabouri Creeks at this time. However, we will be better equipped to provide this information upon completion of the aquatic biological inventories which we plan to conduct in the near future.

The major advantage with dry dam detention is that it would have minor impact on the streams' environment. Detention areas could be developed into wildlife areas by planting flood-tolerant vegetation. Periodic flooding of areas currently outside the streams' floodplains would cause change in the species composition of plant communities at those sites. We expect that flood-intolerant species will perish and be replaced by more tolerant species.

Enlargement and clearing of the floodway of North and South Gabouri Creeks was not discussed during the field inspection. If these features are planned in later planning stages, please notify us and we will provide comments on potential impacts.

As you know, Ste. Genevieve was one of the first European communities west of the Mississippi River. Settlement of this area was due, in large part, to the abundance of fish and wildlife. Given the historic nature of this project and the importance of fish and wildlife resources to development of this community, we strongly recommend that enhancement of fish and wildlife be included as a project purpose. We believe that

through careful planning, flood protection can be provided and fish and wildlife resources enhanced in a compatible fashion.

We look forward to continued coordination on this project.

Sincerely,

Alan L. Balliett

for Joseph A. Janecek
Field Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE

CARBONDALE FIELD OFFICE (ES)
Federal Building, Room 115C
250 West Cherry Street
Carbondale, Illinois 62901

IN REPLY REFER TO:

Commercial: 618-457-3659
FTS: 958-6659

July 14, 1982

Colonel Robert J. Dacey
District Engineer
St. Louis District
Corps of Engineers
210 Tucker Blvd., North
St. Louis, MO 63101

Dear Colonel Dacey:

This Planning Aid Letter describes fish and wildlife problems and needs in the Ste. Genevieve, Missouri area. Opportunities to enhance fish and wildlife resources in conjunction with the proposed Historic Ste. Genevieve Flood Control Project are also discussed. This letter is prepared in partial satisfaction of coordination objectives, under authority of and in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended, 16 U.S.C. 661 et seq.) and the National Environmental Policy Act. We plan to provide an additional Planning Aid Letter on Stage 2 project alternatives, once they are formulated by your staff.

PROBLEMS AND NEEDS

Habitat for wildlife in the watersheds of North and South Gabouri Creeks is excellent. The interspersion of forest, cropland, and pasture land provides a pronounced edge effect. Wildlife habitat in the village of Ste. Genevieve and the Mississippi River floodplain to the east of the community is lower in value because of the highly developed nature of the area. Scarcity of habitat in these two sections of the project area is the major limiting factor for wildlife. Additional food, cover, and nesting sites is a major need.

The lower portion of South Gabouri Creek has been significantly impacted by discharges and runoff from the limestone mining operation. Fish and benthos populations appear to have been significantly reduced as a result of the discharges and runoff from the mining operation. Elimination of this pollution source would improve conditions for the fish and aquatic life in South Gabouri Creek.

OPPORTUNITIES

The proposed flood control project provides an excellent opportunity to create additional wildlife habitat. This could be done by planting wildlife-preferred vegetation on project lands. Trees and shrubs adjacent to levees and floodwalls would provide food, cover, and nesting sites for wildlife in

addition to concealing the structures and making the project more aesthetically pleasing. Such plantings would also provide travel lanes between more open habitats.

Borrow areas could be developed into wildlife habitat. If properly constructed, these areas would make ideal wetland habitat and especially benefit waterfowl during spring and fall migrations.

We look forward to continued coordination on this project.

Sincerely,

Alan L. Balliett

for Joseph A. Janecek
Field Supervisor

cc: MO DOC (Stucky)

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

MARION ILLINOIS SUBOFFICE(ES)
Rural Route 3 - Box 198-A
Marion, Illinois 62959

Commercial: 618-457-3659
FTS: 958-6659

June 2, 1983

Colonel Gary D. Beech
District Engineer
St. Louis District
Corps of Engineers
210 Tucker Blvd., North
St. Louis, MO 63101

Dear Colonel Beech:

This letter is intended to partially provide Fish and Wildlife Coordination Act planning input to your staff regarding the Ste. Genevieve, Missouri flood control study which your office is conducting. Project alternatives were presented by your staff on May 2, 1983. Unfortunately, alternatives were received too late to meet the end of May report submission deadline imposed by your staff.

In order to assist your office in meeting project milestones and have some input into the planning process, we are submitting this letter which we intend to serve as a temporary substitution for the Draft Fish and Wildlife Coordination Act Report. This letter highlights the most important project impacts and enhancement opportunities foreseen as a result of project alternatives. The official Draft Coordination Act Report will be sent to you by the middle of July.

Enlarging North and South Gabouri Creek floodways may have substantial affects on the fishery of these streams unless measures are taken to mitigate impacts. The streams normally have low flows and are typically shallow. Widening the streambed and removing existing pools and riffles as a result of enlarging the floodway would make these areas so shallow during low flows that they would be unable to sustain fish and some other forms of aquatic life. In order to avoid these losses, the stream channel with an appropriate mixture of pools and riffles should be reconstructed during or immediately after enlargement of the floodway. We would be pleased to provide technical assistance in designing the new stream channel.

The proposed levee system may cause increased flood heights and increased flooding in the surrounding floodplain. The potential for these increases occurring should be evaluated as part of the General Design Memorandum for this project.

The proposed levees will cross North and South Gabouri Creeks. It is our understanding that the levees will have removable gates which will be used to block off the streams during flooding conditions on the Mississippi River. We support this concept of removable gates because they would allow for the continued movement of fish between the Mississippi River and the tributary stream habitat during times when the Mississippi River is below flood stage.

We endorse your proposal to construct wetlands in the borrow areas. This would provide an opportunity for development of a bottomland-hardwood forest and slough complex similar to that which once commonly existed along the Mississippi River. The decline of bottomland-hardwood habitat has been identified by the Fish and Wildlife Service as an Important Resource Problem.

A gated outlet for Mississippi Slough should be constructed in the levee to insure unimpeded movement of fishes during low river stages. Existing water levels in the slough should be maintained to protect aquatic life.

Mississippi Slough suffers from sedimentation and has become very shallow in certain areas. Selective sediment removal may restore former fish and wildlife conditions and at the same time provide a source of borrow. An inspection of Mississippi Slough should be held between our respective staffs to further investigate this possibility.

Selective plantings of trees and shrubs at the base of levees and floodwalls would provide an additional source of food, cover, and nesting sites for urban wildlife residing in the area. We suggest plantings be included in the finalized plan.

Sincerely yours,

Joseph A. Janecek

Joseph A. Janecek
Assistant Field Supervisor

cc: MO DOC (Stucky)
US EPA, Kansas City, MO

STE. GENEVIEVE, MISSOURI

APPENDIX J

U.S. FISH AND WILDLIFE SERVICE COORDINATION

PLANNING AID LETTERS COMMENTS AND RESPONSES

The St. Louis District transferred funds to the U.S. Fish and Wildlife Service under the Fish and Wildlife Coordination Act. In a series of planning aid letters the Service commented on problems and opportunities that they observed in the study area. These comments and the St. Louis District's responses are discussed below.

PROBLEMS

Comment.

Wildlife habitat in the village of Ste. Genevieve and the Mississippi River floodplain to the east of the community is lower in value because of the highly developed nature of the area. Scarcity of habitat in these two sections of the project area is the major limiting factor for wildlife. Additional food, cover, and nesting sites is a major need.

Response.

The selected plan has features that will increase the wildlife habitat in the study area, e.g., creating marsh habitat from borrow pits and allowing forest vegetation to develop adjacent to diverted creeks.

Comment.

The lower portion of South Gabouri Creek has been significantly impacted by discharges and runoff from the limestone mining operation. Fish and bentros populations appear to have been significantly reduced as a result of the discharges and runoff from the mining operation. Elimination of this pollution source would improve conditions for the fish and aquatic life in South Gabouri Creek.

Response.

This concern is beyond the scope of the present study.

OPPORTUNITIES

Comment.

The proposed flood control project provides an excellent opportunity to create additional wildlife habitat. This could be done by planting wildlife - preferred vegetation on project lands. Trees and shrubs

adjacent to levees and floodwalls would provide food, cover, and nesting sites for wildlife in addition to concealing the structures and making the project more aesthetically pleasing. Such plantings would also provide travel lanes between more open habitats.

Response.

In designing the alternatives the St. Louis District will take every practical opportunity to incorporate these suggestions. However, we do not plan to purchase additional right-of-way which would take additional prime farmland out of production or to take residential property that is not needed for other project purposes. The right-of-way adjacent to the creek diversions will be allowed to grow in natural riparian vegetation.

Comment.

Borrow areas could be developed into wildlife habitat. If properly constructed these areas would make ideal wetland habitat and especially benefit waterfowl during spring and fall migrations.

Response.

The St. Louis District plans to develop the borrow areas into marsh habitat.

Comment.

Construct low flow channels on widened creeks.

Response.

A low flow channel would be washed out in a few years and is not practical.

Comment.

Obtain hydraulic fill from maintenance dredging.

Response.

Coordination with Channel Maintenance Section of the St. Louis District indicates that the area where fill would be needed is too far from the maintenance dredging activity.

Comment.

Enlarging North and South Gabouri Creek floodways may have substantial affects on the fishery of these streams unless measures are taken to mitigate impacts. The streams normally have low flows and are typically shallow. Widening the streambed and removing existing pools and riffles

as a result of enlarging the floodway would make these areas so shallow during low flows that they would be unable to sustain fish and some other forms of aquatic life. In order to avoid these losses, the stream channel with an appropriate mixture of pools and riffles should be reconstructed during or immediately after enlargement of the floodway. We would be pleased to provide technical assistance in designing the new stream channel.

Response.

The St. Louis District will coordinate with the U.S. Fish and Wildlife Service to determine if any practical measures exist to mitigate the adverse impacts caused by channel widening.

Comment.

The proposed levee system may cause increased flood heights and increased flooding in the surrounding flood plain. The potential for these increases occurring should be evaluated as part of the General Design Memorandum for this project.

Response.

The potential for induced flood heights is discussed in APPENDIX C, HYDROLOGY AND HYDRAULICS. At a 100-year frequency flood the added flood

height would be 0.5 feet. The Prairie du Rocher Levee is approximately the same height.

Comment.

The proposed levees will cross North and South Gabouri Creeks. It is our understanding that the levees will have removable gates which will be used to block off the streams during flooding conditions on the Mississippi River. We support this concept of removable gates because they would allow for the continued movement of fish between the Mississippi River and the tributary stream habitat during times when the Mississippi River is below flood stage.

Response.

Concur.

Comment.

We endorse your proposal to construct wetlands in the borrow areas. This would provide an opportunity for development of a bottomland-hardwood forest and slough complex similar to that which once commonly existed along the Mississippi River. The decline of bottomland-hardwood habitat has been identified by the Fish and Wildlife Service as an Important Resource Problem.

Response.

Concur.

Comment.

A gated outlet for Mississippi Slough should be constructed in the levee to insure unimpeded movement of fishes during low river stages. Existing water levels in the slough should be maintained to protect aquatic life.

Response.

Concur.

Comment.

Mississippi Slough suffers from sedimentation and has become very shallow in certain areas. Selective sediment removal may restore former fish and wildlife conditions and at the same time provide a source of borrow. An inspection of Mississippi Slough should be held between our respective staffs to further investigate this possibility.

Response.

Concur.

Comment.

Selective plantings of trees and shrubs at the base of levees and floodwalls would provide an additional source of food, cover, and nesting sites for urban wildlife residing in the area. We suggest plantings be included in the finalized plan.

Response.

Although planting along levees and floodwalls would jeopardize the soundness of the levees and floodwalls and impede maintenance, selective plantings will be made on other project lands such as those adjacent to the widened creeks.

STE. GENEVIEVE, MISSOURI

FEASIBILITY REPORT

APPENDIX K

CLEAN WATER ACT (SECTION 404(b)) EVALUATION

STE. GENEVIEVE, MISSOURI

APPENDIX K

CLEAN WATER ACT (SECTION 404(b)) EVALUATION

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STE. GENEVIEVE, MISSOURI

APPENDIX K

CLEAN WATER ACT (SECTION 404(b)) EVALUATION

SECTION 1 - INTRODUCTION

This appendix includes a Clean Water Act (Section 404(b)) Evaluation in accordance with Environmental Protection Agency (EPA) guidelines.

The Ste. Genevieve, Missouri, flood control project would involve the placement of dredged and fill materials into waters of the United States. Section 404 of the Clean Water Act of 1977 established a permit program for the purpose of regulating discharges of dredged or fill material into waters of the United States. Under Section 404(b)(1), proposed discharges of dredged or fill material must conform to guidelines developed by the Administrator, Environmental Protection Agency. On 5 September 1975, in accordance with Section 404(b)(1), the Environmental Protection Agency published regulations (40 CFR 230) which outline criteria and procedures for evaluating activities subject to Section 404. On 24 December 1980, revised Section 404(b)(1) guidelines were published (40 CFR 230) which became effective 30 March 1981. It is mandatory that the guidance be applied to all proposed discharges of dredged and fill material subject for approval under Section 404.

SECTION 2 - PROJECT DESCRIPTION

2.1 LOCATION

The project area is located at Ste. Genevieve, Missouri, about 54 miles south of St. Louis (PLATE K-1). Ste. Genevieve is at the edge of the Mississippi River floodplain, on the right bank of the river between river miles 122 and 125. North and South Gabouri Creeks flow through the town and converge on the floodplain. Valle Spring Branch flows into South Gabouri Creek on the floodplain at the east edge of town. The floodplain land between Ste. Genevieve and the river is devoted primarily to agricultural production.

2.2 GENERAL DESCRIPTION

Plan 1 is the alternative that best meets the planning objectives for the project area. It provides an urban design levee that would protect the City of Ste. Genevieve from Mississippi River flooding, widening of the two tributaries to reduce their flooding, and certain recreational and environmental measures on lands needed for flood control. A complete discussion of the features of Plan 1 is given in the Main Report, DESCRIPTION OF THE SELECTED PLAN section.

Those portions of the project area subject to Section 404 jurisdiction are displayed on PLATE K-1 in VOLUME THREE. Not shown on PLATE K-1, but subject (in part) to Section 404 jurisdiction, would be the settling basin(s) in which to dewater the hydraulic fill material.

This feature will most likely follow the proposed levee alignment. Five features or sub-features of Plan 1 would be subject to Section 404 jurisdiction. These features - all flood control improvements - are listed in TABLE K-1.

2.3 AUTHORITY AND PURPOSE

The Ste. Genevieve, Missouri, study is authorized by a resolution introduced by Congressman Parke M. Banta of Missouri and adopted on June 17, 1948, by the Committee on Public Works of the United States House of Representatives.

The purpose of this project is to provide flood damage reduction and related improvements for Ste. Genevieve, Missouri. The town of Ste. Genevieve is a nationally and internationally significant historic resource. The town was founded during the French Colonial period in the 1700's. Many structures built during that period are still standing, and are subject to flooding. The project addresses flooding problems, recreation opportunities, and environmental concerns, especially as they relate to the historic structures and historic setting in Ste. Genevieve.

2.4 GENERAL DESCRIPTION OF DREDGED OR FILL MATERIAL

2.4.1 GENERAL CHARACTERISTICS OF MATERIAL

a. Riverfront Levee: The proposed plan calls for constructing 3.2 miles of levee along the Mississippi River. Fill for

TABLE K-1

STE. GENEVIEVE

PLAN 1 COMPONENTS

SUBJECT TO SECTION 404 JURISDICTION

FEATURE	404 JURISDICTION
1. Riverfront levee - six sections totalling 5,700 feet	Yes
a. Hydraulic dredging in Mississippi River to provide levee fill materials	No
b. Settling basin to dewater hydraulic fill material	Yes
c. Borrow pits riverside of levee to provide levee fill material (41 acres)	Yes
2. Pumping station (footings and backfill) on Gabouri Creek	Yes
3. Gravity drains through levee	
South - on new ditch	Yes
Middle - on Gabouri Creek	Yes
North - on Mississippi Slough	Yes
4. Channel widening and slope protection	
a. 1.83 miles channel widening and slope protection (gabions and (or) riprap) on North and South Gabouri Creeks	Yes
b. Channel widening and slope protection on Gabouri Creek (700 feet) and Mississippi River Slough (4,800 feet)	Yes
5. 6 bridge replacements on North and South Gabouri Creeks	Yes (below OHW)

this feature will consist of clean sands placed hydraulically from the river and clay obtained from riverside borrow pits. The sand will be placed between impervious (clay) retention dikes and form the core of the levee. The retention dikes and additional clay from the borrow sites will form the remainder of the levee and act as an impervious clay blanket for the sand core.

b. Pumping Station. The proposed plan calls for construction of one pumping station (650 cfs) landside of the levee on Gabouri Creek. Fill material for this feature will consist of backfill around the pumping station foundation and wing walls where they extend below the plane of ordinary high water. The backfill will consist largely of silts and clays.

c. Gravity Drains. The proposed plan calls for corrugated metal pipe drains to be installed at three locations through the riverfront levee. Fill material for these gravity drains will consist of silts and clays that will be used as backfill around the structures.

d. Creek Widening and Bank Stabilization. The proposed plan calls for 1.83 miles of stream widening on North and South Gabouri Creeks. Gabions and (or) riprap would be placed along the lower slopes of the creek banks. The gabions will be filled with clean limestone rocks hauled from a nearby quarry.

Gabouri Creek would be widened for approximately 700 feet riverside of the levee, and the channel bottom and side slopes would be lined

with rock riprap to avoid erosion from the pumping station discharges. The riprap would be clean limestone from a nearby quarry.

The Mississippi River Slough will be widened for approximately 4,800 feet to improve interior drainage. This proposed action will involve reshaping of the channel bottom and side slopes. A similar action will be involved in widening Gabouri Creek and lower North and South Gabouri Creeks for interior drainage. Some onsite fill, consisting of silts and clays, will be used in these actions.

e. Bridges. The proposed plan calls for six bridge replacements on North and South Gabouri Creeks. All of these replacements will involve construction below the ordinary high water mark for the above mentioned creeks. Fill material for these features will consist of backfill of silts and clays placed around the concrete piers and wing walls of the bridges where they extend below the plane of ordinary high water.

2.4.2 QUANTITY OF MATERIAL

a. Riverfront Levee. The proposed plan calls for 93,000 cubic yards of hydraulic fill and 5,000 cubic yards of clay fill to be placed below ordinary high water.

b. Pumping Station. The proposed pumping station calls for 1,800 cubic yards of backfill.

c. Gravity Drains. The proposed gravity drains call for 1,000 cubic yards of fill to be placed around the drains.

d. Creek Widening and Bank Stabilization. The proposed plan calls for 3,700 cubic yards of gabions and 5,400 cubic yards of riprap to be placed within the channels of North and South Gabouri Creeks. Each of the creeks will require 7,000 cubic yards of backfill.

The proposed plan calls for 200,000 cubic yards of material to be excavated from Missouri Slough and 83,000 yards of material to be excavated from North and South Gabouri Creek.

e. Bridges. The proposed plan calls for six bridges. The abutments will require 300 cubic yards of backfill below ordinary high water.

2.4.3 SOURCE OF MATERIAL.

a. Riverfront Levee. The hydraulic fill material will be pumped from the Mississippi River Channel. The clay fill material will be hauled from adjacent borrow pits. Suitable excavated material from the channels will also be used.

b. Pumping Station. Backfill material will be obtained from nearby borrow pits.

c. Gravity Drains. Fill material will be obtained from borrow pits.

d. Creek Bank Stabilization. The stone for riprap and gabions will be obtained from local quarries. Backfill will be obtained from borrow pits. Excavated material from the channels will be used as fill; materials not suitable for fill will be placed in borrow pits and graded.

e. Bridges. Backfill will be obtained from borrow pits.

2.5 DESCRIPTION OF THE PROPOSED DISCHARGE SITE(S)

2.5.1 LOCATION

a. Riverfront Levee. The location of the Plan 1 project features is depicted in PLATE K-1. The riverfront levee would be constructed on the floodplain between the City of Ste. Genevieve and the Mississippi River. Levee segments involving the placement of fill into waters of the United States would include those reaches that cross the Mississippi River Slough (2 reaches), Gabouri Creek, South Gabouri Creek, and Valle Spring Branch.

b. Pumping Station. The pumping station is located landside of the levee, where the levee crosses Gabouri Creek.

c. Gravity Drains. Gravity drains would be installed through the riverfront levee at the lower (south) end of Mississippi River Slough, on Gabouri Creek, and on a new drainage ditch near the south end of the levee.

d. Creek Widening and Bank Stabilization. Gabions would be installed either on one or both sides of North and South Gabouri Creeks where widening is necessary. In those sections of creek where gabions are installed on only one side, the bankline on the other side of the creek will be stabilized with rock riprap.

Riprap would be installed along the first 700 feet of Gabouri Creek riverside of the levee, downstream from the pumping station.

Channel widening locations on the Mississippi River Slough and the creeks is depicted in PLATE K-1.

e. Bridges. Six bridges would be replaced - 2 on North Gabouri Creek, and 4 on South Gabouri Creek - within those stream reaches that would be widened.

2.5.2 SIZE

The size in acres of borrow areas and fill sites is given in TABLE K-2. The acreage of borrow sites is a maximum size estimate, assuming riverside borrow pit and hydraulic dredging depths of 5 feet.

TABLE K-2

STE. GENEVIEVE

SIZE IN ACRES OF BORROW OR FILL SITES

FILL MATERIAL SITES	
Riverfront Levee and Gravity Drains	56
Pumping Station	1
Creek Widening and Slope Protection	25
Bridges	2
Total Fill Material Sites	83
BORROW AREA SITES	
Riverside Borrow Pits	41
Hydraulic Dredging Area	245
Total Borrow Area Sites	296

2.5.3 TYPE OF SITE

Most borrowing or creek widening or fill activities will be under confined conditions. Hydraulic dredging material will be placed in a confined settling basin. Gabion rock will be placed in corrugated metal gabion baskets.

2.5.4 TYPE(S) OF HABITAT

The acres of existing habitats at borrow or fill sites is listed in TABLE K-3.

a. Riverfront Levee. Most sections of the riverfront levee will be constructed across currently existing agricultural cropland. Where the levee crosses Gabouri Creek and South Gabouri Creek and Valle Spring Branch, the affected habitat is small creeks with a narrow strip of trees on each side of the creek. The Mississippi River Slough, at the two locations where it is crossed by the levee, is a palustrine permanently flooded unconsolidated bottom wetland, surrounded by a narrow strip of trees and brush.

b. Pumping Station. The pumping station will be constructed off to the side of Gabouri Creek on existing agricultural land. A new entrance channel will be cut for the pumping station through agricultural lands.

TABLE K-3

STE. GENEVIEVE

ACRES OF EXISTING HABITATS AT DREDGING OR FILL SITES

FILL MATERIAL SITES	
Agricultural Cropland	53
Riparian Bottomland Forest	11
Creek	6
Palustrine Wetland	3
Developed	10
Total Fill Material Sites	83
BORROW AREA SITES	
Agricultural Cropland	41
Mississippi River Main Channel and Main Channel Border	245
Total Borrow Area Sites	296

c. Gravity Drains. The northern and southernmost gravity drains will go through the levee on existing agricultural lands. New entrance and exit channels will be cut through agricultural lands for these gravity drains. The middle gravity drain will go through the levee in the existing channel of Gabouri Creek.

d. Creek Widening and Bank Stabilization. The locations where gabions would be constructed along widened sections of North and South Gabouri Creeks is about 50% developed and 50% riparian habitat (bottomland hardwood forest). Rock riprap would be placed on the sloped side of widened sections of these creeks.

Similar bottomland hardwood forest habitat exists in a narrow strip along the bankline of those sections of Gabouri Creek and Mississippi River Slough that would be widened.

e. Bridges. The location of bridge replacements is generally developed and of very low quality as wildlife habitat.

2.5.5 TIMING AND DURATION OF DISCHARGE

Construction could begin in the first year that Congress authorized construction funds, and would take approximately 4 years to complete. Currently, it is anticipated that construction would begin in October, 1988. The first 2 years would be devoted primarily to construction of the levee and appurtenant structures and interior drainage channels. The last 2 years would primarily involve

construction of the pumping station and the channel widening of North and South Gabouri Creeks.

2.6 DESCRIPTION OF DISPOSAL METHOD

River sediments will be hydraulically transported by pipeline to the levee fill site, dewatered in a settling basin, then shaped and compacted in the levee.

Dry soil from borrow pits or creek banks (from widening) will be excavated by conventional earth moving equipment, i.e. scrapers and dozers.

Riprap material will be hauled to the work site by truck and dumped or placed by hand in gabion baskets.

SECTION 3 - FACTUAL DETERMINATIONS

3.1 PHYSICAL SUBSTRATE DETERMINATIONS

3.1.1 SUBSTRATE ELEVATION AND SLOPE

The substrate would be expanded laterally in the area where levee fill materials would be placed. The slope would be essentially unchanged.

After the relocation of Valle Spring Branch, the old channel between the proposed levee and the start of the relocation would be filled level with the natural topography.

3.1.2 SEDIMENT TYPE

Dredging activity during construction will consist of dredging water- saturated soil and placing this material between newly constructed retention dikes (a settling basin). The physical characteristics of the dredged material will be clean sands. The silts and clays from borrow pits will be similar in grain size, shape, and compaction to the material in the creek banks where fill will be placed.

3.1.3 DREDGED OR FILL MATERIAL MOVEMENT

Levee fill material would be promptly compacted and revegetated to avoid erosion into area waterways. The clay blanket covering the dredged hydraulic fill would prevent movement of these sands and control through seepage in a non-damaging manner.

All improved or new ditching, whether landside or riverside of the proposed levee would be promptly revegetated to avoid erosion.

3.1.4 PHYSICAL EFFECTS ON BENTHOS

a. Riverfront Levee. Benthic invertebrates that inhabit the 245 acres of Mississippi River bottom to be dredged will be

mechanically destroyed. Some of these areas will be recolonized within 5-10 years, although some are used as disposal sites for maintenance dredging in the navigation channel.

Benthos in the 9 acres of creek or slough through which the levee will be constructed will be permanently buried by levee fill.

b. Creek Widening and Bank Stabilization. Benthos along the 1.83 miles of North and South Gabouri Creeks to be widened will be destroyed, either mechanically as the stream banks are widened and shaped or by being covered by gabions or rock riprap. However, these areas will be recolonized within 1 year or so, possibly with a different assemblage of organisms. The gabions and riprap will provide a different but favorable substrate for benthic recolonization.

c. Pump Station, Gravity Drains, and Bridges. Construction of these features will have an insignificant effect on benthic invertebrates. A very few benthic organisms may be destroyed as the old bridge supports are removed. A few benthic organisms may colonize the new bridge supports, pump station foundation, or gravity drains, but the surfaces of these structures will be generally smooth and sterile.

3.1.5 ACTIONS TAKEN TO MINIMIZE IMPACTS

The primary action to avoid adverse impacts on the substrate would be to confine construction activities to dry weather periods.

Fill material would be promptly compacted. Both fill material and excavated channel material will be promptly revegetated or riprapped to avoid erosion into adjacent waterways.

3.2 WATER CIRCULATION, FLUCTUATION, AND SALINITY DETERMINATIONS

3.2.1 WATER

a. Salinity. Not applicable.

b. Water Chemistry. There will be some small changes in water chemistry associated with this project. They will mainly be associated with increases in suspended solids when dredging occurs and the creek beds are enlarged. The material to be moved is not considered contaminated and all changes should be of very short duration.

c. Clarity. Short term increases during construction but no permanent effect on normal water clarity.

d. Color. Same as c.

e. Odor. Same as c.

f. Taste. No impact as no water intakes in area.

g. Dissolved Gas Levels. It is not expected that these activities will significantly impact dissolved gas levels.

h. Nutrients and Eutrophication. Some localized increases in nutrient levels could occur during construction but should be of very short duration and thus not cause any eutrophication problems.

3.2.2 CURRENT PATTERNS AND CIRCULATION

a. Current Patterns and Flow. No alteration of flow in this reach of the Mississippi River will occur as a result of providing a levee since the flow area removed is small when compared to flood flow volumes that occur during high water periods. Since part of the right Mississippi River overbank will no longer convey flood flows a small shift in current patterns will occur; in that, the small percentage of flow formerly in the right overbank would be carried in the channel and the left overbank. No alteration of current patterns or flow in this reach will occur as a result of this project during in-bank flows.

b. Velocity. There will be a slight increase in the Mississippi River velocity through this reach of the proposed levee during periods of flood flows. The maximum increase in in-channel velocity for the 100-year discharge would be approximately 1 foot per second.

c. Stratification. The Mississippi River does not experience any significant stratification in this reach of the open river.

d. Hydrologic Regime. The project itself will not cause any changes in surface water runoff due to any altered surface elevations. No significant influence is expected to occur relative to the groundwater.

3.2.3 NORMAL WATER LEVEL FLUCTUATIONS

This project will have no impact on normal water level fluctuations on the Mississippi River. Water levels riverside of the proposed levee will be directly governed by the prevailing Mississippi River stage. River stages for this reach of river fluctuate during different seasons of the year. Usually, higher river stages come in the months of March through June, although high stages can occur and have occurred at any time during the year. An average river stage for this reach of river is approximately 361.71 feet (N.G.V.D.) based on the Little Rock Landing gage at Mississippi River mile 125.5.

3.2.4 SALINITY GRADIENTS

Not applicable.

3.3 SUSPENDED PARTICULATE OR TURBIDITY DETERMINATIONS

3.3.1 EXPECTED CHANGES IN SUSPENDED PARTICULATES AND TURBIDITY LEVELS IN VICINITY OF DISPOSAL SITE

There will be minimal increases in suspended solids at the disposal site. Levels of suspended particulates and turbidity may increase slightly in the immediate vicinity of construction activities in the area waterways. Construction related effects will be minimized by the confinement of hydraulic dredged material.

3.3.2 EFFECTS (DEGREE AND DURATION) ON CHEMICAL AND PHYSICAL PROPERTIES OF THE WATER COLUMN

a. Light Penetration. During construction, short-term localized increases in turbidity will reduce light transmission in areas at and downstream of the work site. The increases should be minor and short term.

b. Dissolved Oxygen. There should not be any significant impact on dissolved oxygen levels as the materials to be used are mostly clean and should have little demand on dissolved oxygen levels.

c. Toxic Metals and Organics. The materials to be used, river-run sand and clay is located in an area not impacted by significant pollutant sources such as industrial sites or pollutant spills. Our Initial Evaluation, or "reason-to-believe" test indicates

a very low probability of the presence of contaminants above background levels.

d. Pathogens. The waters in the vicinity of the work area are not used for recreational pursuits, or as drinking water; therefore, human contact with any potential pathogens would be unlikely.

e. Aesthetics. Increased turbidity during construction dredging will have only minor visual impacts on this area.

3.3.3 EFFECTS ON BIOTA

a. Primary Production, Photosynthesis. No significant effects on primary production in the Mississippi River are expected because of the high ambient turbidity and naturally low primary production levels.

Primary production and photosynthesis would undergo a minor temporary reduction in the immediate vicinity of construction activities in North and South Gabouri Creeks, Valle Spring Branch, and Mississippi River Slough.

b. Suspension/Filter Feeders. Suspension or filter feeding would be minimally disrupted in the Mississippi River as well as the creeks and slough in the project area as a result of increased suspended particulate and turbidity levels. A minor loss of these

feeders would temporarily occur in the immediate vicinity of construction activities.

c. Sight Feeders. No significant effects on sight feeders are expected in the Mississippi River because of the high ambient turbidity level. Diminished light penetration will have a minor adverse effect on the ability of sight feeders to locate food in the creeks and slough. However, this effect would be restricted to the immediate construction site vicinity, and would be of short duration. Recovery and recolonization is expected a short time after construction is complete.

3.3.4 ACTIONS TAKEN TO MINIMIZE IMPACTS

The materials dredged will be mostly clean sands with little pollution potential. All material will be placed in diked disposal areas to control runoff and minimize impacts. The construction activities will take place during dry weather and construction work sites will be planted to prevent erosion.

3.4 CONTAMINANT DETERMINATIONS

The initial evaluation indicates a low probability of the measure of contaminants above background levels.

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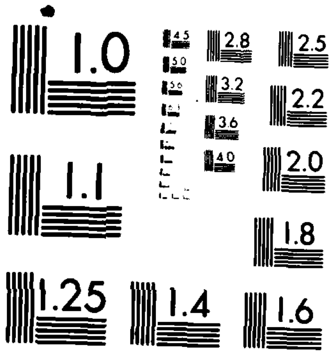

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3.5 AQUATIC ECOSYSTEM AND ORGANISM DETERMINATIONS

3.5.1 EFFECTS ON PLANKTON

The effects on plankton in the Mississippi River will be insignificant, because of normally low numbers of plankton in the river. Plankton production would be eliminated from creek and wetland areas that receive levee fill. Plankton production will be reduced during the construction period in the immediate vicinity of construction activities.

Plankton production may be somewhat increased in creeks landside of the levee due to the elimination of turbid backwaters from the river.

3.5.2 EFFECTS ON BENTHOS

The effects on benthos in the Mississippi River will be minor. Benthos in the dredging areas will be destroyed, but the density of benthic organisms in these areas is low because of the periodic use of these areas for dredged material disposal from main channel dredging.

Benthos in the creek or slough reaches that receive fill will be destroyed. This will be permanent where the levee is put in place. Recolonization will occur in reaches that are widened or receive gabion or riprap fill. The long-term effect should be minor.

3.5.3 EFFECTS ON NEKTON

Nekton will be permanently eliminated from areas that receive levee fill, and temporarily reduced in other construction areas. Recolonization will be rapid, as plankton and benthos (used as food organisms) production recovers.

3.5.4 EFFECTS ON AQUATIC FOOD WEB

The effects on the aquatic food web should be minor. There will be a short-term (1-5 year) loss of energy input from terrestrial sources (leaves from riparian vegetation), but the creek reaches that will be effected are already channelized and low in productivity, so the proposed work should cause no significant long-term changes.

3.5.5 EFFECTS ON SPECIAL AQUATIC SITES

Levee fill in the Mississippi River Slough will permanently destroy approximately 3 acres of palustrine wetland. However, 79 acres of palustrine wetland will be created by construction of the riverside borrow pits. This includes the 41 acres subject to Section 404 evaluation plus an additional 38 acres. See PLATE K-1. A net positive effect on wetlands would accrue.

3.5.6 THREATENED AND ENDANGERED SPECIES

The proposed discharges will not jeopardize the continued existence or modify critical habitat of any threatened or endangered species. Provision has been made for fall and winter tree clearing to avoid possible adverse impacts on Indiana bat nursery colonies.

3.5.7 OTHER WILDLIFE

Increased use of the project area by waterfowl could occur, as a result of the net increase in wetland habitat.

3.6 PROPOSED DISPOSAL SITE DETERMINATIONS

3.6.1 MIXING ZONE DETERMINATIONS

A mixing zone should not be required for any of the work done in this area. All contaminants will be confined and all discharges will be intermittent, so this should not be required.

3.6.2 COMPLIANCE WITH APPLICABLE WATER QUALITY STANDARDS

The proposed activities should not cause any violations of Missouri water quality standards. All actions necessary to prevent water pollution, as required by the Missouri Department of Natural Resources, will be included in the plans and specifications.

3.6.3 POTENTIAL EFFECTS ON HUMAN USE CHARACTERISTICS

a. Effects on Water Supplies. No effects. No water intakes or wells are located in the vicinity of the project.

b. Recreational and Commercial Fisheries. Minor temporary effect. This reach of the Mississippi River is not used for commercial fishing, and very little for sport fishing. The creeks receive only minor use for sport fishing.

c. Water Related Recreation. Disruption of boating or other water related recreation should be insignificant. Boaters may have to slow down to maneuver around the dredge in the river during the construction period.

d. Aesthetics. Aesthetics would incur some minor, construction-site-specific adverse effects during the construction period. However, the long-term aesthetic effects would be positive in nature. The Mississippi River levee, because it would for the most part not be visible from historic areas in town, would not be a visual intrusion. Widening of tributary channels would also be unobtrusive, and in fact would restore them to widths more closely approximating those observed during Ste. Genevieve's early days. Most important is the fact that the plan would eliminate the aesthetic impact of flood fight activities as they are currently conducted, with temporary sandbag levees, other small levees, and associated pumps for seepage and basement flooding. The aesthetics of the more floodprone

neighborhoods would be improved since buildings and property would no longer be threatened with the damages and cleanup that always accompany flooding.

3.7 DETERMINATION OF CUMULATIVE EFFECTS ON THE AQUATIC ECOSYSTEM

The net long-term effects of the proposed action on the aquatic resources in the project area will be minor. These minor impacts will have an insignificant cumulative effect on the aquatic ecosystem.

3.8 DETERMINATION OF SECONDARY EFFECTS ON THE AQUATIC ECOSYSTEM

The net long-term secondary effects of the proposed action on the aquatic ecosystem would be beneficial, accruing from the creation of 79 acres of palustrine wetlands from the borrow pits.

SECTION 4

FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

No significant adaptations of the guidelines were made relative to this evaluation.

Four structural alternative plans were developed in detail. (See Environmental Impact Statement, PLANS CONSIDERED IN DETAIL section). Plan 4 provided for minimum flood protection through clearing and snagging, minor levee development, and floodproofing of one structure. Plans 1, 2, and 3 would achieve flood control through urban design levees, creek channel widening, and conversion of borrow pits to marsh habitat. Adverse impacts of these three plans were similar. Plan 3 was more advantageous in terms of secondary impacts, in that it provided for 108 acres of borrow converted to marsh versus 79 acres for Plan 1, and Plan 3 would protect one additional historic structure. Plan 1 was selected as the best plan to reduce flood damages at Ste. Genevieve primarily because of lower costs than Plans 2 and 3.

The proposed hydraulic dredging of levee fill material and the proposed placement of fill material, widening of creeks, and associated activities should not result in any violations of Missouri Water Quality Standards. These construction activities will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

The proposed placement of fill material will not jeopardize the existence of any Federally-listed endangered or threatened species or their habitats.

The proposed placement of fill material and related construction activities will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, sport and commercial fishing, plankton, fish, shellfish, or wildlife. Minor adverse impacts to the creek and wetland habitats in the project area will be offset by the conversion of 79 acres of borrow pits to wetlands. The life stages of aquatic life and other wildlife dependent on aquatic ecosystems will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values will not occur.

Steps taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem include: (a) a settling basin for hydraulic dredged material, (b) construction during dry weather, (c) compaction and vegetation on barren slopes, (d) channel slopes stabilized with gabions or riprap, and (e) conversion of borrow pits to wetlands.

On the basis of the guidelines, the proposed sites for the discharge of dredged or fill material are specified as complying with the requirements of these guidelines.

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